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A POPULATION ANALYSIS OF THE SUN RIVER ELK HERD, MONTANA

A THESIS

SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL

OF THE UNIVERSITY OF MINNESOTA

BY

Richard Ralph Knight

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

December, 1967

due
JUN 4 1985
FEB 7 1992
JUL 0 1 2009

ACKNOWLEDGEMENTS

I would like to express my appreciation to all of those persons who assisted with the many phases of this study. Special thanks go to two former members of the Montana Fish and Game Department: Mr. G. F. Cole, National Park Service, who provided initial supervision and support and Dr. R. L. Eng, Montana State University, who provided supervision and support from 1962 through 1965. Other former members of the Department who gave their time and assistance are: Mr. A. L. Lovaas, National Park Service, Dr. R. J. Mackie, University of Minnesota, and Dr. H. D. Picton, Montana State University.

Mr. T. H. Leik, Montana Fish and Game Department, assisted with data processing and statistical advice. Other Department members who assisted with the project were: B. G. Goodman, R. Janson, J. McLucas, P. Mihalovich, J. Mitchell, T. Mussehl, M. Rognrud, and A. Schallenberger. Personnel of the Lewis and Clark National Forest gave their full cooperation and assistance throughout the study. My wife, Celia, assisted both in the field and with preparation of materials throughout the study. Mrs. E. Skrukrud has typed several drafts of the manuscript. Dr. W. H. Marshall, University of Minnesota, reviewed and made several improvements in the manuscript.

The writer was employed by the Montana Fish and Game Department under Federal Aid Project W-98-R for the duration of the study. Financial aid for trapping and marking was given by the Allen Foundation.

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INTRODUCTION

The Sun River Elk Herd ranges in the upper Sun River drainage along the Continental Divide in West-central Montana. One of the state's important elk herds (*Cervus canadensis*), it is composed entirely of native stock that has built up from a small remnant left at the turn of the century. From an estimated population of 200-300 animals in 1910, the herd increased to a peak of approximately 5,000 in 1930 (Cooney 1940). It presently numbers between 2,000 and 3,000 animals (Lovaas *et al.* 1966). As described by Picton (1960a) most of these animals migrate between summer ranges along the Continental Divide and winter ranges in valley bottoms and foot-hills at the eastern edge of the mountains.

One of the problems connected with the herd is poor calf production. Smith (1930) estimated the annual survival increase (percentage of increment surviving to yearlings) at 14 percent. The highest calf:cow ratio in recent years was .40 in 1958 (Casagranda 1958). Ratios in other recent years have ranged between .15 and .36. Present investigations were undertaken to determine possible causes and remedies for poor production.

Field work spanned the period from April, 1960 through August, 1965. Supplemental data were gathered during the 1965-66 hunting season and in the summer of 1966. At first, field work was concentrated on range use habits on the fall, winter and spring ranges to determine whether or not forage deficiencies were probable. Later, from the fall of 1963 to the fall of 1965, marked animals were used to gain more information on migratory patterns and population structure. Data on production trends as expressed by calf-

per-cow ratios and pregnancy rates were gathered throughout the study.

Other than the major winter range, the study area lies within the Bob Marshall Wilderness Area and equally inaccessible country around it. Relatively inefficient horse and on-foot travel were the only methods of transportation used until late 1963 when helicopters were utilized. Consequently, a portion of the data was gathered during the period between August, 1963 and August, 1965.

THE STUDY AREA

The study area (Figure 1) embraces approximately 800 square miles of the upper Sun River drainage 15 miles west of Augusta, Montana. The North Fork of the Sun River (Sun River in Figure 1 and referred to as such hereafter) flows eastward through the area forming the border between Lewis and Clark County to the south and Teton County to the north. The Lewis and Clark National Forest includes the area from the east face of the mountains west to the Continental Divide. Approximately two-thirds of the area is included within the Bob Marshall Wilderness Area. Elevations range from 4,900 feet in foothill areas to 9,000 feet in the mountains (although relatively little elk habitat is found above 8,000 feet).

Physiography

The entire region reflects the results of the last glaciation. The headwaters of most streams emanate from cirques that are typi-

Figure 1. Relief photo looking west over the study area and showing general topography and major streams.

cal summering areas for the elk herd. The valley floors, where elk usually winter, are mantled with debris left by the retreating glaciers.

A small portion of the area including the Game Range (lower left of Figure 1) and the area north of it along the east face of the mountains lies within the High Plains physiographic province (Mudge 1965b). The topography is typical of glacial deposition with low rolling hills mantled with a thin layer of glacial drift separated by shallow coulees and numerous potholes. Gray, olive-drab and gray-green mudstones interbedded with sandstone of the Two Medicine Formation underlie most of the area (Mudge 1965a). Soils are mainly stoney and gravelly loams of the Scobey and Williams types (Gieseker 1937, 1947).

Much of the area lies within the mountainous topography comprising the Northern Rocky Mountain Plateau (Mudge 1965b). From the east face of the mountains west to the valleys of the North and South Forks, topography is characterized by narrow mountain valleys underlain by mudstones separated by sharpt north-trending ridges leading up to the Continental Divide. Red, tan and gray mudstones underlie most of the area.

Climate

Climatic conditions are subject to variation with the wide range of elevations and topographic features within the area. Prevailing weather patterns develop from the west, giving rise to general down-slope wind conditions. Weather information is taken

from the U. S. Weather Bureau Station at Gibson Dam situated within the Sun River Canyon at an elevation of 4,590 feet.

A summary of the monthly temperature and precipitation records taken from the 25-year average (U. S. Weather Bureau 1960) is given in Figure 2. Precipiation averages 17.24 inches annually with over one-third falling during May and June. The mean annual temperature is 41.7° F with January the coldest month with an average temperature of 22.7° F and July the warmest month with an average of 62.4° F. Temperature extremes during the period of study were -31° F in January, 1962 and 100° F in August, 1961.

Within the mountainous area, the ground is generally snow covered from November through April with variations according to elevation and topography. A summary of Snow Survey measurements taken by the Soil Conservation Service on March 1 is given in Table 1. The locations are all above 5,000 feet elevation and do not reflect conditions over the entire area. The average snow depth at each location during the study period was lower than the 1949 to 1965 average.

The weather is characterized by strong, west winds often exceeding 40 miles per hour. This is especially true along the face of the mountains and within the west-trending canyons. The transition from foothills to mountains is generally abrupt, with sheer cliffs rising up to 3,000 feet above the surrounding country. That portion of the area east of the mountain face is subject to much more pronounced downslope wind conditions than the area within the mountains and receives less snow accordingly. The snow that

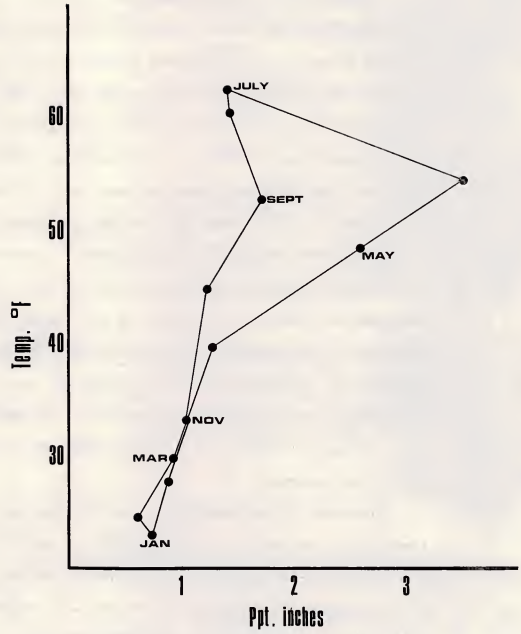

Figure 2. Climograph depicting average monthly precipitation and temperature at Gibson Dam for the 25-year period ending in 1960.

does fall in the foothills rarely persists over 3 days without a general removal by the strong west winds.

TABLE 1. SUMMARY OF MARCH 1 SNOW MEASUREMENTS IN THE SUN RIVER AREA, 1949-1965.

		Average Depth on Snow Course in Inches	
Location	Elevation	1949-1965	1960-1965
Cabin Creek	5400	26.9	24.4
Five Bull	5700	21.9	16.6
Wrong Creek	5700	46.4	41.6
Goat Mountain	7000	38.2	34.0
Wrong Ridge	6800	59.7	54.1

History of the Herd

Little information is available on the status of the elk prior to 1910. Smith (1930) mentions that early, large herds which ranged in the foothills were driven into the mountain with settlement of the country beginning in about 1856. By the early 1900's, it was estimated that only a remnant herd of 200-300 elk remained in the upper Sun River drainage. Koch (1941) was unable to find any elk in this area in 1905 and 1906.

In 1913, the Montana Legislature established the Sun River Game Preserve for the protection of the elk herd. This Preserve consists of 199,661 acres of rough mountainous terrain bounded by

the North and South Forks of Sun River on the east and extending west to the Continental Divide. In the same year, the United States Forest Service conducted a count of the herd recording a total of 965 animals. They estimated a total herd of between 1,000 and 1,500 head.

Concurrent with establishment of the Game Preserve, the Forest Service removed all grazing permits from the Preserve area to favor the elk. This left 5,975 cattle and horses grazing the mountainous area east of the Preserve for a 6-month season and 735 cattle and horses for a 3½-month season in 1913. In continuing effort to favor elk, domestic grazing use was gradually reduced to 3,300 cattle and horses for a 3½-month season in 1932 and 1,093 cattle and horses for a 3½-month season in 1939. At the present time approximately 840 cattle and 290 horses graze the forest for a 3-month period. Since many of these are not in areas commonly used by elk, there probably is very little competition for forage between elk and domestic livestock.

Coincident with establishment of the Game Preserve and reduction of livestock competion the elk began to increase, reaching an estimated peak population of 5,000 animals by 1930 (Cooney 1940). By the winter of 1927-28, deteriorating forage conditions within the mountains forced noticable numbers of elk on to private land in the foothills for the first time since the mid-1800's. In 1930, after increasing complaints from ranchers, the Montana Fish and Game Department initiated attempts to "herd" elk off private lands and hold them in the mountain valleys. Herding efforts had little effect other than harassment and the

problem intensified through the 1930's into the 1940's.

In 1948 the Fish and Game Department established the Sun River Game Range by purchase and lease of 20,000 acres of foothill lands south of the mouth of Sun River Canyon for elk winter range (Figure 1). Between 412 (Rognrud 1963) and 2600 (Janson 1961) elk, depending on the severity of winter conditions, have used the Game Range each winter since its purchase. Since 1954 management practices for the herd have been directed mainly toward reducing the herd to a level consistent with the carrying capacity of the available winter range and holding it at that level.

In addition to the elk herd, the area supports populations of mule deer (*Odocoilus hemionus*), whitetail deer (*O. virginianus*), bighorn sheep (*Ovis canadensis*), mountain goat (*Oreamnos americanus*), black bear (*Ursus americanus*) and grizzly bear (*U. horribilis*). Scientific names are taken from Burt and Grossenheider (1952).

VEGETATION

General vegetation zones roughly follow the sequence described by Larson (1930) for Central Montana with transition from prarie to juniper-limber pine to Douglas-fir-lodgepole pine with a subalpine forest of Engelman spruce, alpine fir and limber pine at highest elevations.

Vegetative types were separated with the objective of defining gross aspects that could be easily classified by visual

recognition with reference to observed animal use. The existence of many extremely varied topographic and geologic conditions dictated either a simplified or very complex investigation of the vegetation. For the purposes of this study it was decided to simplify the separation of types as much as possible. Botanical nomenclature follows Booth (1950) and Booth and Wright (1959).

Grasslands

Quantitative data on vegetative composition were gathered by estimation of percentages of canopy coverage after Daubenmire (1959). A 2 x 5 dm. plot fram was placed on the ground at intervals in a pre-determined pattern and each plant species was tabulated according to which of six percentage classes its canopy occupied within the plot. Percentage classes were 1, 0-5 percent; 2, 5-25 percent; 3, 25-50 percent; 4, 50-75 percent; 5, 75-95 percent; and 6, 95-100 percent. The midpoint of each percentage class was used when interpreting the data. A series of 40 plots was used on most sites and each series of plots was arranged within a 20 x 50 foot rectangular area judged to be representative of the type being sampled. In some cases where pre-existing range transects were present, the series followed a straight line coincident with the transect.

Grassland covers approximately 8,000 acres on the Sun River Game Range and another 7,000-8,000 acres in the mountain valleys. Areas along the face of the mountains to the north and south of the Game Range also contained grassland but were relatively lit-

tle used by elk throughout this investigation. This type is comparable to the "Grassland" described by Picton (1960) for the valley of the North Fork of Sun River and the "bunchgrass" described by Schallenberger (1965) for the Sun River Canyon. For the purposes of classification of animal usage, all grassland was considered as one major type though composition varied from communities like the Palouse Prairie (Daubenmire 1942) in the foothills to a fescue grassland similar to that described by Moss and Campbell (1947) in the mountain valleys. Four types of vegetative composition were recognized in the grasslands. The quantitative data on species composition is presented in Table 2.

Agropyron-Festuca. Most of the Game Range, the canyon area described by Schallenberger (1965) and part of the North Fork valley (NFSR in Table) exhibit this composition. Bluebunch wheatgrass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*) and rough fescue (*F. scabrella*) were the major grasses present. Wheatgrass dominated on the drier sites, the fescues prevailed on more moist and deeper soils. Bluegrasses (*Poa compressa*, *P. pratensis* and *P. secunda*) and junegrass (*Koeleria cristata*) occur commonly while blue gramma (*Bouteloua gracilis*), needle and thread (*Stipa comata*), and muly (*Muhlenbergia cuspidata* and *M. richardsonis*) are locally common. Forbs are essentially the same as listed by Schallenberger (1965). Spreading mats of horizontal juniper (*Juniperus horizontalis*) are common along with fringed sage (*Artemisia fridgida*), cudweed sagewort (*A. ludoviciana*) and shrubby cinquefoil (*Potentilla fructosa*).

TABLE 2. MAJOR COMPONENTS OF THE GRASSLAND TYPE.

Species	Agropyron-Festuca		Danthonia-Festuca				Stipa-Festuca Potentilla Festuca	
	Game Range (6) 1/	RFSR (3)	Game Range (1)	Exclosure (1)	RFSR (1)	Exclosure (1)	(6)	(3)
Agropyron								
spicatum	11/75/100 2/	12/72/100	+/13	10/73	--	--	+/4/16	--
Festuca								
idahoensis	8/79/50	17/97/100	25/93	18/95	10/79	15/72	12/61/100	10/46/100
Festuca								
scabrella	10/57/100	2/60/67	4/43	14/75	+/1	26/50	8/54/100	8/22/100
Stipa								
richardsonii	--	--	--	--	+/+	2/11	21/86/100	--
Danthonia								
parryi	1/10/33	3/31/67	26/83	1/10	26/96	5/27	3/26/83	--
Poa spp.	1/20/100	7/53/100	1/15	+/13	4/45	--	2/17/83	3/37/67
Potentilla								
fruticosa	+	+	--	+	+	3/11	--	29/68/100
Danthonia								
intermedia	--	--	--	--	--	--	--	10/46/100

1/ Numbers in parentheses indicate number of stands sampled.

2/ Average canopy coverage for all stands/average frequency of occurrence for stands where present/constancy/ percentage of stands within type containing species.

Danthonia-Festuca. Parry's oatgrass (*Danthonia parryi*) is the dominant grass throughout the type on areas which are unprotected from grazing. This plant is described as an increaser under grazing in the fescue grassland of Alberta (Moss and Campbell 1947). This situation apparently occurs in the portions of the study area covered by grassland. Within two exclosures on this type Parry's oatgrass declined in favor of rough fescue (Table 2).

An exclosure on the Game Range constructed in 1948 shows increases of rough fescue and bluebunch wheatgrass under portection with a corresponding decrease in oatgrass. Idaho fescue also declined under portection of this exclosure. The exclosure on the North Fork of Sun River, in existance since 1934, shows greater recovery of rough fescue and Idaho fescue. Forbs and shrubs with the exception of horizontal juniper are essentially the same as in the Agropyron-Festuca type.

Stipa-Festuca. The valley of the North Fork of Sun River supports this type from its lower end up to Biggs Creek (Figure 1). The type is similar to the agropyron-festuca type with the exception that bluebunch wheatgrass is replaced by Richardson's needlegrass (*Stipa richardsonii*). Distribution of this type coincides roughly with the exposure of the Two Medicine Formation in the lower North Fork. Associated species are similar to the composition found in the Agropyron-Festuca type.

Potentilla-Festuca. Shrubby cinquefoil, which is commonly associated with rough fescue throughout the area in small amounts, assumes a dominant aspect in grasslands in the vicinity of Biggs Creek. The area covered by this type is relatively moist compared with other grassland areas and has also been subjected to heavier past grazing pressure by cattle. Much of the area covered by this type was seeded by the Forest Service in the 1930's after heavy grazing had removed most of the native grasses and timothy (*Phleum pratense*) and orchard grass (*Dactylus glomerata*) are now common constituents. A greater abundance and variety of forbs was also noted on this type.

Limber Pine Savannah

A transitional zone above the grassland along the east face of the mountains supports an open limber pine (*Pinus flexilis*) savannah where underlain by sandstones. Grass cover is similar to the Agropyron-Festuca type although bluebunch wheatgrass is characterized more by its single-culm vegetative form than the typical bunchgrass form and western wheatgrass (*Agropyron smithii*) assumes almost equal status. Horizontal juniper and silky lupine (*Lupinus sericeus*) also thrive on the sandy soils characteristic of this type. Exposed ridges of sandstone in the drift area also support this type.

Timber

Timber communities within the area have been described by Picton (1960a) and Schallenberger (1965). Rather than duplicate the

above descriptions, only a brief summary of each type is given here.

Aspen. Quaking aspen (*Populus tremuloides*) groves are interspersed with grassland on more moist sites throughout the area. Relationships with grassland and understory flora are essentially as described by Lynch (1955) for Glacier County north of the study area. Aspen stands in Sun River Canyon have been described by Schallenberger.

Lodgepole pine-aspen. This type (not separated by the above authors) often occupies early stages of succession sites eventually to be dominated by lodgepole pine (*Pinus contorta*) and eventually Douglas-fir (*Pseudotsuga taxifolia*). All gradations, from almost pure aspen groves surrounded by pine and fir to scattered aspen within the pine, are found. The major importance of the type from the standpoint of this study is that understory species are more typical of the aspen type and furnish some forage. Dandelion, western yarrow (*Achilla milliflorum*), elk thistle (*Cirsium foliosum*), strawberry (*Fragaria* spp.), asters (*Aster* spp.), Oregon grape (*Berberis repens*), northern sweetvetch (*Hedysaraum boreale*) and geranium (*Geranium richardsonii*) were common understory plants.

Lodgepole pine. Lodgepole pine is the dominant timber species with an understory grading from an almost barren carpet of pine needles to dense stands of pinegrass *Calamagrostis rubescens*). This is a seral stage preceding the Douglas-fir type and young

Douglas-fir types are common in most stands.

Douglas-fir. Douglas-fir is the dominant timber species often associated with scattered lodgepole pine. Pinegrass is the major understory species.

Subalpine forest (closed-canopy). Engelman spruce (*Picea engelmanni*) is the dominant tree in association with alpine fir (*Abies lasiocarpa*) and, frequently, whitebark pine (*Pinus albicaulis*). Understory vegetation, often very sparse, is characterized by heartleaf arnica (*Arnica cordifolia*) with gooseberry (*Ribes inermis*) and smooth menziesia (*Menziesia glabella*) common on some sites.

Subalpine forest (open-canopy). This community was characterized by more open stands of Engelman spruce and alpine fir often with Douglas-fir, lodgepole pine, limber pine and whitebark pine (Figures 3 and 4). Beargrass (*Xerophyllum tenax*) and low huckleberry (*Vaccinium scoparium*) dominate the understory with interspersed forbs. Frequently small park-like areas dominated by an abundant growth of forbs occur.

Other Types

A variety of open areas, which were of great importance to elk, were also present in the study area. Their existance depended on historical events or drainage condtions. Since they were not studied in detail only a brief description is made of them.

Burns. Burns occurred within the lodgepole pine, Douglas-fir, and subalpine forest. Typical vegetation of burns in the lodgepole pine and Douglas-fir types has been described by Schallenberger. Several of the burns on moist, east-facing slopes differ from Schallenberger's description. They were characterized by greater regeneration of both Douglas-fir and lodgepole pine. In addition to plants listed by Schallenberger, velvet snowbush (*Ceonothus velutinus*) and elk sedge (*Carex geyeri*) were common in the understory.

Most of the extensive open areas on the summer range are the result of 50 to 60-year-old burns in the open canopy subalpine forest. Those areas designated as burn habitat in this investigation were those where standing dead trees, falling trees, and scattered re-growth of both Engelman spruce and alpine fir were evident. Beargrass interspersed with patches of forbs was the common understory type. The rest of the open area on summer range is described under forb and beargrass types below.

Beargrass. Large areas at higher elevations were dominated by beagrass and low red huckleberry similar to the understory of the subalpine forest. Most of the type occurred in areas of old, non-regenerating burns. This corresponds to the beargrass subtype described by Picton (1960a).

Forb. This corresponds to the forb and mixed subtypes of Picton (1960a). It occurred at high elevations where it graded into the beargrass and subalpine forest types.

Figure 3. The open canopy spruce-fir type at the head of Lick Creek. The Continental Divide is at upper right.

Figure 4. Ground view of open canopy spruce-fir. The forb complex typical of more open spots is in the foreground. Tall culms close to the trees are flowering stalks of beargrass.

Bottom. This type was found along creeks, river bottoms and in poorly drained meadows. Bottoms on the Sun River Game Range are former hayfields supporting dense stands of sloughgrass (*Carex* spp.) timothy, brome (*Bromus inermis* and *B. marginatus*) and bluegrasses. Creek and river bottoms were characterized by lush herbaceous growths. Dandelions (*Taraxicum officinale*), cinquefoils (*Potentilla diversifolia* and *P. Glandulosa*) brome, bluegrasses, sticky geranium (*Geranium viscosissimum*) and common camas (*Camasia quamish*) were common constituents.

Park. This type did not have a characteristic flora but rather was an arrangement of openings in the timber. Parks were classified according to the timber type in which they occurred.

RANGE HABITS

Throughout the study, all observed elk were recorded as to sex, age as well as the vegetative type and location where seen. During the period April, 1960 through August, 1963, almost all observations were made from the ground. Observations were made along established routes traveled by motor vehicle on the winter range and on foot and horseback on the transitional ranges. Observations on summer range were sporadic during this period. From September, 1963 through August, 1965, regular observation routes were also traveled by helicopter. Observations from motor vehicle and helicopter were usually made between one-half hour before sun-

rise and 2 hours after sunrise and from approximately 2 hours before sunset to darkness. Observations from on foot or horseback were made throughout the day.

During 1960, 1961 and 1962, information on forage preferences on most commonly used vegetative types was gathered by examinations of feeding sites (Knowlton 1960). After a group of animals was observed feeding, the observer went to the feeding site and recorded instances of recent use on each plant species. Each bite or what was assumed to be one bite on a single species was recorded as one instance of use. If two species of plant occurred in one bite an instance of use was recorded for each species. Analysis of feeding site information followed the aggregate percentage method of Martin *et al.* (1946) where instances of use were expressed as a percentage for each examination and averaged for each vegetative type.

Since this herd is migratory most animals used different range areas as the seasons progressed. The study area was divided into winter, summer and transition (spring and fall) ranges on the basis of observed use (Figure 5). Some transitional range and, to a lesser extent, was used by a few elk at all seasons. In this case they were classified according to the season of peak use. Seasons were divided into spring, April 1 through June 15; summer, June 16 through September 15; fall, September 16 through December 31 and winter, January 1 through March 31.

Amount of time spent by elk on each of the three general range areas was about equal at about 4 months each (Table 3).

Winter ranges supported the most animals from January through April, or well into the spring period. Peak populations were observed on transition ranges in May and June and November and December. Heavy spring use of transitional ranges was usually finished by mid-June, after which relatively few animals were observed due to migration through heavy timber cover to summer ranges.

Summer range use reached a peak abruptly in July and declined through August and September as conditions became progressively drier in the high mountain basins and the animals made greater use of timber types. The slight reversal of the downward trend observed in October may have been due to the opening of hunting season on the transitional ranges. Several individually marked elk were observed to move from the summer range to the transitional ranges in September and then back to summer ranges after hunting began. Fall use of the transitional ranges increased as inclement weather conditions at the higher elevations forced the animals downward. Heaviest use of the transitional ranges occurred in December, after the hunting season. Actual intensity of use in relation to total amount of area covered by each range type (Figure 5) showed heavy use on winter range and progressively lighter use on transitional and summer ranges.

The mean elevation at which animals were observed throughout the year followed the expected pattern, lowest in winter and highest in summer with spring and fall months slightly higher than winter (Table 3). The slight interruption in the downward movement during the fall was again reflected by the rise in the mean

TABLE 3. YEARLY RANGING HABITS OF ELK BY ELEVATION AND RANGE AREAS, SEPTEMBER, 1963 THROUGH AUGUST, 1965.

	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Range Type												
(% of elk observed)												
Summer	7	4	5	3	1	13	97	78	59	64	23	1
Transition	3	1	1	12	61	74	2	12	38	34	76	97
Winter	90	95	94	85	38	13	1	10	3	1	1	2
Elevation												
Mean	5105	5259	5095	5084	5295	5470	7079	6919	5976	6336	6003	5228
Mode	5100	5100	4300	5100	5100	5100	7400	7400	7400	7500	5300	5100
TOTAL NUMBER OBSERVED	1262	3787	5885	4925	3105	2258	2145	756	372	580	1213	1577

observed elevation during October. Very little change in elevation was noted between the winter and transitional ranges, since elevations of the canyon and foothill winter ranges and the floor of the valley of the North Fork of Sun River, where most of the transitional use was observed were similar. On one isolated range in the southern part of the study area the animals reamined at about 7,000 feet elevation throughout the winter.

The elevations where most animals were observed each month for winter and spring (mode, Table 3) generally coincided with the higher elevations of grasslands on the Sun River Game Range and the grassland flats in the North Fork of the Sun River. Most of the elk observations in the summer months coincided with the elevation of the cirque floors along the Continental Divide. An abrupt change in elevation (1,600 feet) was observed from June to July when the elk move upward from transitional to summer range. The downward movement at the end of summer was less abrupt and was complicated by the hunting season as well as the Sun River Game Preserve.

Since seasonal changes were accompanied by changes in forage use and/or range type, ranging habits and forage preferences characteristic of each season will be discussed separately.

SPRING

Early spring use was concentrated on winter ranges with an increasing trend to the transitional ranges as the season progressed (Table 3). Most of the elk take advantage of new growth on the

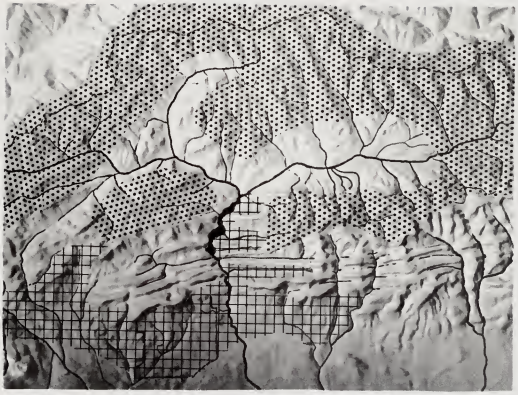

Figure 5. Distribution of range types within the study area. Dotted area is summer range and checked area winter range. Unmarked area enclosed by summer and winter ranges is the transitional range. Unmarked areas at top and bottom of the figure are out of the study area.

winter ranges through April before moving to the transitional ranges in May and June.

Grassland received the greatest observed use throughout spring (Table 4). Use of this type was greatest in April and declined to less than 50 percent by June. Actual patterns of grassland use probably decline much faster than indicated during May and especially June, since there was an obvious observational bias in favor of grassland and bottom types compared to timber types. This was well expressed by the total animals observed for each month. Only 58 percent as many animals were observed in May as compared to April and the 15-day period of June shows only 26 percent as many animals as observed in April (Table 4). It is clear that animals become less observable during May and June of most years and, by deduction, are making more use of timber types.

A further measure of observational bias was obtained during the springs of 1964 and 1965 when a helicopter was used for most observations. Percentages of animals observed on the open bottom types declined in favor of parks and timber types during these 2 years for all months, although the trends expressed in Table 4 remained the same. This is attributed to relatively better coverage of parks and timber by aerial survey as compared to ground travel.

Use of bottoms remained fairly constant. They received only slightly more use in April and June than in May. Heavier use during April reflected earlier spring "green up" and more succulent plants on bottoms compared to surrounding grasslands. In June, the bottoms continued to support succulent vegetation while some of the

higher areas had begun to dry up. Fluctuations in use varied from 3 percent in 1965 to 17 percent in 1960, apparently depending on prevailing moisture conditions.

Declining use of the limber pine savannah was more an expression of migration away from the winter range, the only place where this type was present, than a change in preferences for vegetative types. Ground cover within this type was not sufficiently different from that of grassland to necessitate a change in vegetative type use to obtain preferred forage.

Aspen groves were used to the greatest extent on transitional ranges and, thus, did not receive very much use during April. Use of aspen during May and June fluctuated widely between years and cannot be attributed to change in observational technique (helicopter). Percentages of animals observed using aspen groves in May varied from 1 percent in 1965 to 28 percent in 1964, (helicopters were used both years). Aspen grove use during June varied from 1 percent in 1965 to 49 percent in 1961. These fluctuations did not correlate with phenology or differences in patterns of use on other types.

Observed use of other timber types remained fairly constant throughout the spring; although, as explained earlier, actual use probably increased during May and June.

Significant increases in observed use of park types reflected increased use of timber types, since parks occur only in the timber. The parks used most frequently during the spring period were in the Douglas-fir type followed by those in aspen-lodgepole

TABLE 4. PERCENTAGES OF ELK OBSERVED ON DIFFERENT VEGETATIVE TYPES DURING THE SPRING PERIOD.

Vegetative Types	Month			
	April[1/] (11,384)	May (6,646)	June (1,441)	Season (19,471)
Grassland	74	65	60	70
Bottom	7	4	7	6
Limber Pine Savannah	10	7	2	8
Lodgepole Pine	1	2	3	1
Aspen	1	7	5	4
Lodgepole Pine-Aspen	2	2	4	2
Douglas Fir	3	2	1	2
Park	2	9	17	6
Other		2	1	1

1/ Number of animals shown in parentheses.

pine and lodgepole pine. Thirty-nine percent of animals observed in parks during the springs of 1964 and 1965 occurred where Douglas-fir was the surrounding timber type while 32 and 19 percent occurred in parks surrounded by aspen-lodgepole and lodgepole pine, respectively. The other 10 percent occurred in aspen.

Stevens (1966) observed decreasing percentages of elk using open grassland types from April through June on his Crow Creek study area. Almost all of his observed spring use in timber types occurred in parks.

Observed use patterns were similar for bulls and cow-calf groups, though actual use probably trended toward higher use of timber types by bulls. Bulls were consistently less "observable" during the study. A total of 13,046 cows and calves were classified during the spring period compared to 770 bulls older than 1 year. This is attributed to a greater use of timber types by bulls rather than the expression of an actual sex composition.

Spring Forage Preferences

Preference is used here in the sense of Heady (1964) as denoting selection by the animal. The common occurrence of any plant in a feeding site examination is regarded as a preference for that plant over other plants available. Preference may be influenced by palatibility of the plant (inherent characteristics which elicit a selective response by the animal concerned), availability of other plants, soil type, and time of year.

Examination of 86 feeding sites totaling 8,354 instances of

use indicated a definite early preference of grasses in April, declining through May to a preference for forbs in June (Table 5). One browse species, Oregon grape, comprised only 1 percent in one feeding site examination on the lodgepole pine type.

Preferred forage species on grassland during April were mainly the three major grasses of the type, though not necessarily in proportion to their abundance. Rough fescue was taken most frequently, and often appeared to be sought out by the elk while leaving all other plant species untouched. Actual consumption of this species was higher than indicated by the table since the use of one plant may involve several actual bites on a robust specimen measuring up to 1 foot in diameter. Gaffney (1941) reported almost complete destruction of a stand of rough fescue by elk at Big Prairie Ranger Station in the South Fork of the Flathead. Idaho fescue appeared second in preference with bluebunch wheatgrass third.

Bluegrass and needlegrass were the only other plants commonly utilized during April. On the Sun River Game Range the common species available was needle and thread while on all transitional ranges it was Richardson's needlegrass. Columbian needlegrass (*Stipa columbiana*) was readily taken whereever encountered by the animals.

A further measure of preference between the three main grasses was provided by utilization transects on the winter range. These transects were measured each spring to determine the amount of winter and spring utilization that various grass species had received

TABLE 5 . SPRING FORAGE PREFERENCES BY MONTH AND VEGETATIVE TYPE AS DETERMINED BY 84 FEEDING SITE EXAMINATIONS.

Species 1/	VEGETATIVE TYPES									
	Grassland			Bottom			Aspen		Lodgepole Pine	
	April (25) 2/	May (39)	June (6)	April (1)	May (5)	June (5)	May (1)	June (1)	May (1)	June (1)
Agropyron Spicatus	11/76 3/	2/23	--	--	--	--	--	--	--	--
Agropyron spp.	--	3/17	6/33	11	10/40	6/25	--	--	--	--
Bromus spp.	--	--	11/66	--	--	12/50	--	5	--	4
Calamagrostis rubescens	--	--	--	--	--	--	--	--	39	--
Danthonia spp.	--	2/35	--	--	--	--	--	--	--	6
Festuca idahoensis	27/88	7/46	--	15	5/40	--	--	--	--	--
Festuca scabrella	43/96	10/43	--	7	6/40	1/25	--	--	--	--
Phleum pratense	--	2/17	1/17	--	17/40	--	--	1	--	--
Poa spp.	7/44	13/59	3/17	23	15/60	8/25	--	--	--	--
Stipa spp.	7/56	5/28	5/50	--	--	--	--	--	--	--
Camassia quamash	--	12/46	2/50	--	--	--	--	--	--	--
Carex spp.	--	3/54	4/50	5	3/40	2/50	8	--	--	--
Other grass and grass-like	4	3	5	--	7	1	2	--	--	--
Total grass and grass-like	99	61	35	61	63	30	10	6	39	13
Agoseris glauca	--	11/49	11/33	--	2/20	--	1	5	--	12
Aster spp.	--	5/47	7/100	35	4/60	16/75	7	3	1	4
Arnica spp.	--	2/20	--	--	3/20	--	18	--	--	--
Cirsium foliosum	--	--	--	--	--	1/25	2	2	6	--
Dodecatheon spp.	--	2/15	--	--	--	--	--	--	--	--
Erigeron spp.	--	4/36	3/33	4	10/60	--	--	4	--	9
Fragaria spp.	--	--	--	--	--	--	9	4	6	7
Geranium richardsonii	--	--	--	--	--	--	20	--	--	--
Geranium viscosissimum	--	--	--	--	--	--	20	29	--	22
Microseris spp.	--	3/20	2/17	--	--	5/75	--	--	--	2
Potentilla spp.	--	1/28	3/50	--	2/60	2/75	--	--	7	--
Taraxicum officinale	--	5/36	34/66	--	2/40	38/100	1	23	3	17
Trifolium spp.	--	2/16	--	--	--	8/25	--	--	--	--
Zizia aptera	--	--	--	--	5/20	--	8	20	25	10
Other forbs	1	4	6	--	9	--	4	4	12	4
Total forbs	1	39	65	39	37	70	90	94	60	87
Berberis repens	--	--	--	--	--	--	--	--	1	--

1/ Species contributing at least 1% on one type during one period.
2/ Figures in parentheses refer to number of feeding sites involved.
3/ Aggregate/percentage / Frequency on types with more than one feeding site examination.

during the preceding winter-spring period. Sampling procedures have been described by Cole (1957). Each transect was assigned one or two "key species" on the basis of abundance and prior knowledge of animal preference. One hundred plants of each species were examined for winter and spring utilization on each transect each spring period from 1961 through 1964. On four transects where Idaho fescue and bluebunch wheatgrass were measured together, utilization of fescue averaged 17 percent of the plants examined and 1 percent for the wheatgrass. On three transects where rough fescue and bluebunch wheatgrass were measured together, utilization of fescue averaged 27 percent of the plants examined compared to less than 1 percent for wheatgrass. On two transects where rough fescue and Idaho fescue were measured together, utilization of rough fescue averaged 42 percent compared to 21 percent for Idaho fescue. An order of preference putting rough fescue first, Idaho fescue second and bluebunch wheatgrass third seems clearly indicated for the April period.

Elk appeared to prefer previously grazed plants to those that had old growth present. This was particularly true of fescuses where the previous year's growth remains in relatively upright, rigid position obscuring the new growth. Only 5 percent of all spring grazing on rough fescue and 2 percent on Idaho fescue involved plants that had remained ungrazed during the winter. One feeding site examination on the bottom type during April showed preponderent use of bluegrass, which was abundant on the type and in a later stage of development than on other types. Two forbs,

aster and daisy (*Erigeron* spp.), were also taken on this type.

May forage preferences were characterized by gradual change to major use of forbs and much greater variety of plants. Twenty-seven species and/or genera (11 grasses, 15 forbs and 1 half-shrub) each contributed 1 percent or more of the use on the various vegetative types in May compared to five grasses and two forbs in April.

Grass and grass-like plants still dominated the diet on the grassland type for May as a whole, although the trend was from heavy grass use early in the month to high percentages of forbs later in the month. Use of the items forming the bulk of the April diet declined as more species contributed new growth to the range complex. Common camas, bluegrass, and rough fescue were important items; each contributed 10 percent or more to the diet. False dandelion (*Agoseris glauca*) followed by aster and common dandelion were the major forbs taken.

Preferences on the bottom type during May followed the same pattern of grass and forb use as occurred on grasslands but common timothy was the major grass and daisies the major forb used.

One feeding site in the aspen type exhibited heavy use of forbs with geraniums and arnica (*Arnica* spp.) making up over 50 percent of the utilization. Sedge was the only grass-like plant contributing 1 percent or more to the diet in this type.

One feeding site in the lodgepole pine type during May indicated a heavy use of pinegrass with all other utilization comprised of forbs, mostly meadow parsnip. This was the only indi-

cation of significant use of pinegrass throughout the study. Although examinations of feeding sites in the timber were very few, use of plant species was noted whenever encountered and other than this one feeding site, only rare use was noted for pinegrass. Use of geraniums and meadow parsnip appeared to be common within the timber.

One feeding site in the limber pine savannah during May showed use very similar to the grasslands, and use on one feeding site examined in a small swamp was comprised of 100 percent sedges.

During June, forbs made up the majority of the species taken on all types. Variety of diet was less than May with nine grasses and eleven forbs comprising 1 percent or more of the total use in one or more vegetative types.

The use of plants that were important in the diet early in the spring on the grasslands declined sharply in June, with bluebunch wheatgrass and the two fescues unused. Bromegrass, mostly mountain brome (*Bromus marginata*), became the most commonly eaten grass with wheatgrass second. Common dandelion was the most heavily utilized plant with false dandelion also forming an important part of the forage used on this type.

Preferences on the bottom type followed those on grassland, except that bluegrass was used to a greater extent among the grasses and aster replaced false dandelion as the second most used forb. Common dandelion remained the most heavily utilized plant.

In the timber types, some brome grass was used in both aspen

and lodgepole pine types and oatgrass (*Danthonia intermedia*) received the greatest use of any grass in the lodgepole pine. Sticky geranium was the most commonly utilized forb, with common dandelion second.

The patterns of spring forage preferences are essentially the same as found by other investigators. Rouse (1957), Kirsch (1962), and Stevens (1966) all report an early preference for grasses changing to a preference for forbs later in the season. Cole (1965) reported a similar change from grasses to forbs from mid-April through June in Grand Teton National Park. This appears to be a common pattern of forage preferences for elk, although Young and Robinette (1939) reported preference for grasses and sedges until mid-July. Blood (1966) reported a predominance of grasses and sedges with a high incidence of browse in spring rumen samples taken at Riding Mountain National Park. Morris and Schwartz (1957) reported over 90 percent grasses in rumen samples taken throughout the spring months on the National Bison Range.

SUMMER

During the last half of June many of the elk were moving through relatively dense subalpine forest enroute from transitional to summer range. Consequently, most of the animals were observed on transitional range (grass types, Table 6), in more open timber types, or in parks in the timber (Table 6). Toward the end of the month a few animals began to show up on the forb and burn types on the summer range. Most of the parks where elk were observed

TABLE 6. PERCENTAGES OF ELK OBSERVED ON VARIOUS VEGETATIVE TYPES DURING THE SUMMER PERIOD.

Vegetative Types	MONTH				
	June (1,410) 1/	July (2,629)	August (1,123)	September (235)	Season (5,397)
Grassland	37	2	6	14	12
Bottom	5	2	1	6	3
Forb	1	38	12	14	22
Spruce Fir	-	18	30	4	16
Beargrass	-	5	2	1	3
Burn	7	22	21	14	16
Douglas Fir	1	1	2	1	1
Lodgepole Pine	2	2	3	8	3
Other Timber Types	8	-	6	14	4
Park	39	10	17	24	19

1/ Number of animals shown in parentheses.

were in the Douglas-fir type. Percentages of elk observed on comparatively open summer range types (Forb, burn, and beargrass) were similar to those observed by Picton (1960a) for subalpine barrens as a whole.

In July numbers of observable elk reached a peak for the summer season. The forb type, which receives the greatest amount of use over the season, was heavily utilized with burns and open-canopy subalpine forest receiving most of the balance of observed use. A definite decline was noted in use of grass and park types as most of the animals reached summer range. A few animals spent the summer on the transitional and winter ranges.

Elk were often observed in the vicinity of persistent snowbanks during July (Figure 6). This included loafing on and around the snowbank as well as intensive use of the succulent vegetation at the retreating periphery. As a result of this activity, areas covered by the snowbanks were often almost barren of vegetation when the snow did disappear.

The cooler microclimate associated with the vicinity of the snowbanks is probably the greatest attraction. Although the succulent vegetation was extremely heavily used, there was not enough volume of forage to attract the relatively large numbers of elk associated with this microenvironment. There was no evidence that the snowbanks were used to escape biting flies as suggested for reindeer (*Rangifer tarandus*) by Formazov (1946: 11). Investigators who have discussed the effects of biting flies on elk (Johnson 1951; Brazda 1953; Cole 1963, 1965) do not mention use of snowbanks as

Figure 6. A group of elk occupying the vicinity of a summer snowbank. Foreground vegetation is predominantly beargrass with patches of forbs.

refuge from flies.

In August use of the open forb and beargrass types decreased sharply and there was a slight increase in numbers of animals using the grass types on transitional ranges. Percentages of animals observed on the forb type dropped to less than one-third of the July figure. Increased use of timber types during this period was reflected by the drop in total number of animals observed as well as the observed increases in use of open-canopy subalpine forest and park types. This was apparently in response to desiccation of vegetation on the exposed types similar to that described by other authors (Kirsch 1962; Stevens 1966). Use of the burns did not change significantly from July to August, possibly because the protection afforded by the debris and slight reforestation served to keep vegetation succulent longer.

Douglas-fir still contained the most parks used by elk with 36 percent of the elk observed in parks occurring with Douglas-fir as the surrounding timber type followed by parks in the closed-canopy subalpine forest and the lodgepole-aspen types with 29 and 25 percent respectively.

During September, numbers of observable elk reached a low for the year. As in late June, most of the elk apparently were in timber between summer and transitional ranges. Use of the burns and open-canopy subalpine forest dropped considerably, while numbers of elk observed on the transitional grass and bottom types increased slightly. The slight rise in use of the forb type over that observed for August is of little significance since it prob-

ably reflected ease of observation on that type rather than an actual use pattern.

Parks within Douglas-fir were the most used again followed by those in aspen-lodgepole and lodgepole pine. Elk occurring in other timber types during this period were mostly in the lodgepole-aspen type at lower elevations on transitional range.

Cole (1964) observed herbland (apparently similar to forb type in this investigation) to be used by elk to a greater extent than any other type from late June through August in Grand Teton National Park. He also observed -oniferous forest types to be used to a greater extent from the last half of August through October. Stevens (1966) observed most of the summer use in grass-forb parks with an increase in use of the lodgepole pine type during September.

Only three feeding site examinations were made during the summer period, all on the forb type during July. Results of 347 instances of use indicated almost equal utilization of forbs and grasses. Fifty-four percent of the total use was on forbs and 46 percent on grasses. Alpine bluegrass (*Poa alpina*) was the most heavily used plant followed by buttercup (*Ranunculus* spp.), daisies and asters with 15, 12 and 9 percent respectively. Other plants used were brome grass, wheatgrass, sedges, elk thistle, false dandelion, and milkvetch (*Astragalus miser*).

Results of other investigators vary in respect to preferred summer forages of elk. Cole (1963) found that forbs made up between 53 percent 95 percent in feeding site examinations on vari-

ous vegetative types. Pickford and Reid (1943) reported that forbs comprised over 80 percent of the summer diet; and Stevens (1966) reported 76 percent occurrence of forbs in feeding site examinations. Blood (1966) reported grass and forbs occurrence in rumen samples at 22 and 26 percent respectively with browse the major item in the diet. Morris and Schwartz (1957) found high percentages of grass during all months in rumen samples from the National Bison Range, with August the only month where grass totaled less than 90 percent.

FALL

Fall is similar to spring in that the elk occupy approximately the same ranges. However, it was apparent from the number of animals observed (19,471 for the spring period compared to 5,813 for the fall period) that the animals spend a greater proportion of their time in the timber types during this period. Movements of the elk were influenced by the hunting season, generally extending from the third week in October to the third week in November. Habitat utilization patterns were characterized by increased use of grassland as the season progressed (Table 7).

Use of parks during the fall mainly involved those in Douglas-fir. Sixty-five percent of all elk observed were using parks within Douglas-fir, 18 percent in lodgepole pine, and 15 percent in lodgepole aspen. A few animals were still observed using forb parks within the closed canopy subalpine forest in late September and early October.

During the last half of September increased numbers of elk were observed on the grass type at the expense of parks and burns as compared to early September. A few animals still remained on the summer range as indicated by occurrence on forb, burns and subalpine open-canopy types.

Since most of the open grassland type occurs outside of the Sun River Game Preserve, most of the occurrence on this type was recorded prior to the hunting season in October and after the season in November. About one week before hunting season, when outfitting camps began to move into the hunting area, the elk began to leave the open grasslands and moved into the relatively dense lodgepole pine, lodgepole aspen and Douglas-fir types within the Game Preserve. That some elk moved all the way back to summer range was reflected by increased use of burns in October as compared to September and the use of the beargrass type during October and November which was higher than observed during the summer months. This fall upward movement as observed with individually marked animals will be discussed further in the section on harvests.

Almost immediately after the hunting season, large numbers of elk began to move from timber types in the Game Preserve into the grassland areas. In December they began to form the winter pattern of vegetative type use with high numbers on the grassland type and with none observed in the types characteristic of the summer range, i.e., forb, burn, beargrass, and open-canopy subalpine forest.

TABLE 7. PERCENTAGES OF ELK OCCURRING ON VARIOUS VEGETATIVE TYPES DURING THE FALL PERIOD.

Vegetative Type	September 1/ (263)	October (675)	November (1,888)	December (2,983)	Season (5,813)
Grassland	33	25	55	69	58
Bottom	3	-	4	2	2
Forb	14	11	1	-	2
Lodgepole Pine	18	10	1	-	2
Lodgepole Aspen	3	5	3	12	8
Douglas-fir	8	1	2	3	3
Burn	7	16	4	-	3
Open Canopy Subalpine	3	9	5	-	3
Beargrass	-	7	8	-	3
Park	11	15	17	6	11
Other	-	1	-	8	5

1/ Number of animals observed shown in parentheses.

Fall Forage Preferences

Examination of twenty feeding sites totaling 1,937 instances of use indicated an increasing preference for grasses on the grasslands as the season progressed, and a change from use of forbs to browse in the bottoms. No feeding site observations were made during October, however, data were supplemented by rumen samples taken during the hunting season (7 in October and 13 in November).

Forage preferences on grassland during September were fairly evenly divided between forbs and grasses. Grass use was concentrated entirely upon timothy, bluegrass and sedges, which had retained their succulence in the moister areas at this time while most other grasses had cured. The only other plant taken on the grass type during this period was aster. Use on one September feeding site in the lodgepole aspen type was composed entirely of green forbs with dandelions, elk thistle and asters comprising the bulk of the items taken.

The contents of seven rumen samples collected during October, 1960 contained 66 percent grass, 21 percent forbs and 13 percent browse. The most prevalent identifiable forbs in the rumens were lupine, western yarrow and horsetail (*Equisetum* spp.). The most prevalent identifiable browse species were Oregon grape, huckleberry, and quaking aspen. Grasses were not identified in the rumen samples.

One November feeding site examination on the grassland type recorded use of cured Richardson's needlegrass, bluebunch wheatgrass and rough fescue. Dotted blazing star (*Liatris punctata*)

TABLE 8. FALL FORAGE PREFERENCES BY MONTH AND VEGETATIVE TYPE AS DETERMINED BY 20 FEEDING SITE EXAMINATIONS. 1/

Species 2/	VEGETATIVE TYPES						
	Grassland			Bottom		Lodgepole Aspen	
	September (2) 3/	November (1)	December (8) 4/	November (1)	December (5)	September (1)	December (2)
Agropyron spicatum	--	15	15/75	--	--	--	3/50
Agropyron spp.	--	--	--	2	--	--	--
Bromus spp.	--	--	--	--	2/20	--	--
Calamagrostis rubescens	--	--	--	--	--	--	1/50
Calamagrostis canadensis	--	--	--	--	6/20	--	--
Danthonia spp.	--	--	4/63	--	--	--	--
Festuca idahoensis	--	--	9/50	--	--	--	--
Festuca scabrella	--	9	21/88	--	--	--	16/50
Phleum pratense	17/50	--	--	19	1/20	--	--
Poa spp.	29/50	-	1/13	79	2/20	--	1/50
Stipa spp.	--	43	35/88	--	--	--	--
Carex spp.	8/100	--	3/25	--	20/60	--	--
Total Grass and Grass-like	54	63	88	100	31	0	25
Achilla millifloras	--	--	1/50	--	--		--
Aster spp.	46/50	3	--	--	--	23	--
Cirsium foliosum	--	--	--	--	--	26	--
Erigeron spp.	--	--	--	--		7	--
Fragaria spp.	--	--	--	--	-	4	2/50
Listris punctata	--	34	--	--	--	--	--
Lupinus sericeus	--	--	1/13	--	-	--	--
Stellaria spp.	--	--	2/25	--	--	--	--
Taraxicum officinale	--	--	--	--	--	37	--
Other Forbs	--	--	2	--	--	3	2
Total Forbs	46	37	6	--	--	100	4
Artemisia ludovicians	--	--	4/13	--	--	--	--
Betula glandulosa	--	--	--	--	35/80	--	31/50
Elaegnus commutata	--	--	--	--	10/20	--	--
Pinus contorta	--	--	--	--	2/20	--	-
Populus tremuloides	--	-	1/13	--	4/40	--	18/100
Potintilla fruticosa	--	--	1/25	--	1/20	--	2/50
Salix spp.	--	--	-	-	17/40	-	3/50
Vaccinium scoparium	--	--	--	--	--	--	17/50
Total Browse	--	--	6	--	69	--	71

1/ No feeding site examination during October.
2/ Species contributing at least 1% on one type during one period.
3/ Figures in parenthesis refer to number of feeding sites involved.
4/ Aggregate percentage/frequency on types with more than one feeding site examination.

and asters, which were still green, made up the rest of the observed use. One feeding site examination made on the bottom type was comprised of 100 percent green grasses represented by bluegrass, timothy and wheatgrass.

The contents of 13 rumen samples collected during November, 1960 were similar to those of October with 65 percent grasses, 19 percent forbs and 16 percent browse. Identifiable plants were also the same with the addition of one forb and four browse species: elk thistle, cudweek sagewort, fringed sage, velvet snowbush and Douglas-fir.

All December feeding site examinations were made coincident with a snow cover varying from one to two feet on grasslands and up to three feet on bottoms. A distinct preference for cured grasses, mostly Richardson's needlegrass, rough fescue and bluebunch wheatgrass, was observed on the grasslands. A few forbs, mostly western yarrow, lupine, and chickweed (*Stellaria* spp.) were taken along with some browse composed of cudweed sagewort, aspen, and scrubby cinquefoil. The remainder of the use was comprised of sedges, bluejoint (*Calamagrostis candensis*), bluegrass, bromegrass, and timothy, which had retained a green condition under the heavy snow cover. To obtain the sedges and grasses, the elk had "pawed out" circular excavations about four feet in diameter. Use figures of browse probably reflected abundance rather than preference. Aspen and willow were taken in lesser amounts than bogbirch, but were also less abundant on the type. Further, approximately 100 percent of the aspen and willow plants available were

taken while relatively few available bogbirch plants were browsed.

Observed utilization on the lodgepole aspen type in December also indicated heavy use of browse, with bogbirch and dwarf huckleberry comprising the bulk of the items taken. Cured grasses, fescue, bluebunch wheatgrass and pinegrass made up most of the balance of use along with occasional forbs.

Fall food preferences were similar to those found in the Gravelly Mountains by Rouse (1957) with the exception that he reported less (3 percent) browse use and more forb use (31 percent). Blood (1966) reported 55 percent browse, 37 percent grasses and sedges and 8 percent forbs in four fall rumens collected in Riding Mountain National Park. Grasses made up 77 percent of the contents of four elk rumens collected during October in the Pecos Wilderness, but browse made up 95 percent of the contents of seven rumens collected from the Gila National Forest during December (Lang 1958).

WINTER

During the winter period the largest numbers of observed animals were on the Sun River Game Range. Numbers of animals using other parts of the winter range (Figure 5) were dependent upon the severity of the winter conditions. The number of observable elk increased during January and February and reached a peak in open grassland areas during March (Table 9).

There was greater variation in vegetative type use between years during the winter than any other season. Use of the grassland type averaged over the season varied from a low of 59 percent

TABLE 9. PERCENTAGES OF ELK OCCURRING ON VARIOUS VEGETATIVE TYPES DURING THE WINTER PERIOD.

Vegetative Types	January 1/ (5,079)	February (8,775)	March (12,519)	Season (26,373)
Grassland	80	71	73	74
Bottom	-	5	11	8
Limber Pine	9	15	6	10
Douglas Fir	4	5	2	3
Burn	3	2	5	3
Park	2	1	2	1
Other	2	1	1	1

1/ Number of animals observed shown in parentheses.

of the observed use in 1965 to 90 percent of the observed use in 1962. This variation is probably best explained by differences in seasonal weather patterns between years and associated changes in migration patterns. In severe winters larger numbers of elk migrate down to the Sun River Game Range and, thus, are observed on the open grassland types. Under moderate winter conditions, greater proportions of elk occupy the winter ranges in Sun River Canyon (Figure 5) and relatively greater numbers are observed on Douglas-fir and burn types. During very mild winter, the percentages of elk observed on grassland type will again be great due to the fact that greater numbers of elk are able to spend the winter on transitional ranges where extensive grassland type occurs.

Under exceptionally severe circumstances the elk may use the timber in preference to grassland. The general trend on the Sun River Game Range under deep snow conditions is for the elk to move from the timber to the grasslands where wind has removed the snow. During 1965, when the lowest percentages of observed elk used the grassland type, snow conditions were such that the elk were forced to remain in the timber. A heavy snowfall early in February, followed by light thaw and a period of very severe cold conditions before the wind could remove the snow cover, resulted in grassland areas on the Sun River Game Range being covered by a foot deep mantle of snow with an overlying three-quarters inch layer of ice. The few animals observed on the grassland types at this time appeared to have difficulty in obtaining traction on the glazed crust. Consequently, most of the elk observed during this period

were on the limber pine savannah where the crust conditions did not form.

Under normal conditions the grassland type receives the greatest amount of use throughout the season, although it is evident when comparing the number of animals observed during each month (Table 9) that large numbers of elk were not being observed during January and February and were probably using timbered types. Use of the bottom type, beginning in February was coincident with occurrence of new, green growth of bluegrass and timothy. Browse plants on bottoms were also utilized during periods of general snow cover on the Sun River Game Range, since the snow seldom gets deep enough to hinder elk movements.

Observed elk use of the limber pine type (Table 9) was probably higher for February than actual over a long period of years, due to the higher percentage of animals found there during 1965. Heavy use of the limber pine type usually coincided with periods of stormy weather or after a general snowfall before the snow on the grassland type has been blown away.

As in the other seasons observed use of the timber types was light due to poor visibility. Most of the timber use appeared to concentrated in Douglas-fir with relatively little use in lodgepole pine, and lodgepole-aspen mixed. This was borne out by observations in the park type where 81 percent of the animals observed in parks were in those surrounded by the Douglas-fir, and only 13 percent and 6 percent in the lodgepole pine and aspen types, respectively.

Percentages of animals observed on the burn type during winter varied with the number of animals wintering in Hannan Gulch, the only area where significant numbers were observed to use the type. This variation did not appear to coincide with weather conditions, but rather to some "whim" of the animals. No animals were observed on the burn type during the winters of 1962 and 1963 but were observed there during the winters of 1961, 1964 and 1965. During 1965 a small group of animals, including three tagged incividuals, was observed to use burns in Hannan Gulch for the entire winter; while other small groups with marked individuals appeared to use Hannan Gulch only enroute between Big George Gulch to the west and Green Timber Gulch to the east.

Winter Forage Preferences

Examination of 46 feeding sites, totaling 4,832 instances of use indicated that grasses and grass-like plants were highly preferred on all types throughout the winter. Bluebunch wheatgrass, rough fescue, Idaho fescue, and needlegrass were the most commonly used plants on the grassland type (Table 10).

High utilization of bluebunch wheatgrass may be a reflection of abundance rather than preference since, similar to the spring, rough fescue and Idaho fescue appeared to be more preferred but were not as widely distributed or as abundant as bluebunch wheatgrass. On five utilization transects where rough fescue and Idaho fescue were measured together, an average of 67 percent of the rough fescue plants examined were utilized compared to 44 percent

Idaho fescue. On seven transects where Idaho fescue and bluebunch wheatgrass were measured together, utilization of Idaho fescue averaged 44 percent compared to 11 percent of the bluebunch wheatgrass plants examined. On seven transects where rough fescue and bluebunch wheatgrass were measured together utilization of rough fescue averaged 52 percent as compared to 11 percent for bluebunch wheatgrass. One transect where Idaho fescue and Parry's oatgrass were measured together Idaho fescue received 12 percent utilization compared to 0 percent utilization of Parry's oatgrass. This is the same order of preference as observed during the spring (namely rough fescue, Idaho fescue and bluebunch wheatgrass). Use of needlegrass in February and March was mostly on Richardson's needlegrass on the North Fork of Sun River.

The apparent heavy use of sticky pointloco (*Oxytropis viscida*) resulted from three feeding site examinations made on the same day. All three contained this plant and nothing else. The three sites were on different parts of the Game Range and involved 989 animals. When using pointloco the elk grazed at a relatively fast pace, going from one plant to the other at a constant, slow walk. It appeared that all of the animals observed developed a preference for this plant for a short period of time. Pointloco was taken at only one other feeding site during the winter. None of the many published winter food habit studies on elk mention a similar short term preference phenomenon.

Excluding the three feeding site examinations containing sticky pointloco, the percentages of grass used during March are

TABLE 10. WINTER FORAGE PREFERENCES BY MONTH AND VEGETATIVE TYPE AS DETERMINED BY 46 FEEDING SITE EXAMINATIONS.

	VEGETATIVE TYPES								
	Grassland			Bottom		Burn			Lisbert Pine
1/ Species	January 2/ (8)	February (8)	March (12)	February (3)	March (3)	January (9)	February (1)	March (1)	February (1)
	3/								
Agropyron spicatum	49/100	27/88	13/75	--	5/100	5/50	--	--	14
Danthonia parryi	4/25	12/88	--	--	--	--	--	--	--
Festuca idahoensis	16/50	5/75	15/89	--	--	1/13	--	--	2
Festuca scabrella	19/75	15/88	21/83	--	--	4/63	7	--	3
Phleum pratense	--	5/13	--	27/66	--	--	--	--	--
Poa spp.	--	6/38	4/58	33/33	61/66	--	--	--	--
Stipa spp.	4/25	20/50	14/92	7/33	4/33	--	--	--	--
Carex geyeri	--	--	1/16	--	--	77/100	93	77	--
Carex spp.	--	--	--	1	--	--	--	--	--
Other Grass and Grass-like	--	--	4/25	--	--	--	--	--	--
Total Grass and Grass-like	92	92	72	70	70	88	100	77	19
Astragulus spp.	1/13	--	--	--	--	--	--	--	--
Lupinus sericeus	--	--	--	--	--	--	--	--	81
Oxytropis viscida	--	--	23/33	--	--	--	--	--	--
Other Forbs	4	--	1	--	1	--	--	4	--
Total Forbs	5	0	24	0	1	0	0	4	81
Acer glabrum	--	--	1/8	--	--	3/13	--	--	--
Amelanchier alnifolia	--	--	1/8	--	--	--	--	--	--
Artemisia frigida	2/13	--	--	--	--	--	--	--	--
Berberis repens	--	--	1/8	--	--	1/13	--	18	--
Ceanothus velutinus	--	--	--	--	--	8/63	--	--	--
Juniperus horizontalis	1/13	7/13	--	--	--	--	--	--	--
Populus tremuloides	--	1/13	--	2/33	--	--	--	--	--
Prunus virginiana	--	--	--	--	28/33	--	--	--	--
Salix spp.	--	--	--	28/33	--	--	--	--	--
Other browse	--	--	1	--	1/33	--	--	1	--
Total Browse	3	8	4	30	29	12	0	19	0

1/ Species contributing at least 1% on one type during one period.
2/ Figures in parenthesis refer to number of feeding sites involved.
3/ Aggregate percentage/frequency on types with more than one feeding site examination.

comparable to those of January and February at 91 percent. Use on feeding site examination in the limber pine savannah probably reflects a short term preference for dried lupine similar to that observed for pointloco. Several of the utilization transects mentioned above were located in the limber pine savannah indicating that forage preferences there were similar to those found on the grassland type.

Palatable browse plants were taken when available. Other than horizontal juniper which was common throughout the grassland type, browse plants were relatively scarce on winter ranges. Even in burn and bottom types, where browse is relatively abundant, grasses and grass-like plants appear to be preferred. The high preference of grass and grass-like plants on the bottom and burn type may have been due to the green condition at the time they were taken. Both timothy and bluegrass were showing new, green growth under the snow in bottoms during February and March. Elk sedge, which is very highly preferred on the burn type, remains green throughout the winter period.

Grasses and sedges appear to be preferred winter elk forage if available. Gaffney (1941) and Rush (1932) found grasses and sedges to be preferred even though browse may be the main item of subsistence. The three most commonly taken grasses during this investigation (rough fescue, Idaho fescue, and bluebunch wheatgrass) were also found by Gaffney to be highly palatable in the adjacent South Fork of the Flathead River, as were the two major browse plants (willow and chokecherry). Grasses and forbs are the winter

staples of elk in Rocky Mountain National Park (Gysel 1959). Hoskins and Dalke (1955) reported bunchgrasses to be the most important winter forage for elk in southeastern Idaho, although some browse was eaten. Cowan (1947) reported the elk diet in Jasper Park to be 97 percent grasses and believed this to be higher than natural due to destruction of desirable trees and shrubs. Cliff (1939) reported heavy winter browse use by elk in the Blue Mountains of Oregon, but this might have been due to scarcity of grasses on the poor range. Buechner and Swanson (1955) report that bluebunch wheatgrass provides over 90 percent of the winter diet of elk in much of the Blue Mountains of Washington.

RANGE RESPONSES

Trends in range conditions on the Sun River Game Range, the major wintering range of the elk herd, were measured by means of condition and trends transects as described by Cole (1958). With this method, key species of grass are chosen for measurement on permanent transects established on representative portions of the range. One hundred plants of each key species are measured on each transect. Plants were classified according to form class, measured for maximum leaf height and a density index measured from the examiners toe after a random number of steps. Results for each transect are expressed as percentages of plants in each of the form classes (young, normal, hollow-center, and clump-edge), average maximum leaf height, and a density index which expresses the average distances between plants in tenths of feet.

To convert the three measurements obtained from each transect into a more easily used figure, they were combined into a "Condition index" as follows: The number of young and normal plants for each transect was multiplied by the average leaf height for the transect and then divided by the density index. Increases in numbers of normal and young plants, along with increases in average leaf height reflect favorable range trends while an increase in the density index indicates lower densities and hence, poorer range conditions.

Condition and trend transects have been measured on the Sun River Game Range each year since 1957. Rnage trends as reflected by five transects using Idaho fescue as the key species and four transects using rough fescue as the key species for the period 1958 through 1963 are graphically portrayed in Figure 7. Trends reflected by six transects on bluebunch wheatgrass during the same period are given in Figure 8. Since much of the bluebunch wheatgrass on the Sun River Game Range occurs in the single culm vegetative form, it is not measured according to form class. The condition index for this species was obtained by dividing the maximum leaf height by the density index.

Percentages of plants utilized during the winter period were measured on the same transects each year since 1961. Average winter utilization of rough fescue for 1961, 1962 and 1963 was 63 percent, 82 percent and 26 percent, respectively. Utilization of Idaho fescue during the same period was 46 percent, 77 percent and

3 percent; and utilization of bluebunch wheatgrass was 9 percent, 35 percent and 0 percent.

Grass conditions were apparently at their best in 1959. Although utilization data were not available for this winter, use probably was quite high as a result of heavy snow and large numbers of elk on the Sun River Game Range.

The downward trends for all species in 1960 coincided with a similar drop in precipitation. Precipitation trends (data from U. S. Weather Bureau 1958 through 1963) for the period 1958 through 1963 are given in Figure 9. The precipitation figures are not totals for the calendar years but the total amount of precipitation from the end of one growing season to the beginning of the next growing season. For example, the figure for 1958 represents the total amount of precipitation falling from August 1, 1957 until July 31, 1958.

Fluctuations in range conditions since 1960 did not directly reflect grazing pressures in all years. Declining trends took place when relatively few elk used the range, and the upward trends for Idaho fescue and bluebunch wheatgrass in 1962 took place after increased winter utilization.

The variation in response among the three grass species after 1960 can probably be attributed to the differential grazing pressures on each. Bluebunch wheatgrass, which received the lightest use, continued to improve through 1963 and it did not appear to be seriously affected by the reduction in precipitation during the

1963 growing season. Idaho fescue did not begin recovery until 1962, then dropped again in 1963. These plants may not have recovered sufficiently from the 1960 drought to respond to even the light grazing pressures in the face of the decreased precipitation in 1963. Rough fescue has been slow to show improvement in the face of the utilization it receives. The very slight upward trend on this grass in 1963 may have been due either to light use that year or sampling variation. Rough fescue may not have been as adversely affected by reduced moisture of 1963 as Idaho fescue since its distribution was limited to more moist sites. Campbell *et al.* (1956) reported that this grass is "grazed out" fairly readily.

The one exclosure on the Game Range gives evidence that rough fescue has been retarded by grazing in this area (Table 2). Both bluebunch wheatgrass and rough fescue were much more in evidence within the exclosure than outside while Idaho fescue was less common inside. Parry's oatgrass was markedly more abundant outside the exclosure. Continued heavy utilization of rough fescue may result in its replacement by Parry's oatgrass on favorable sites. While this would probably have little effect on the pounds per acre of forage produced, it could effect elk range-use patterns. The effect of replacing rough fescue with Parry's oatgrass within the Danthonia-Festuca type probably would be increased use and possible downward trends on the Agropyron-Festuca type.

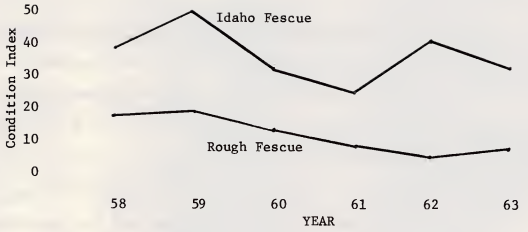

Figure 7. Condition trends of rough fescue and Idaho fescue on the Sun River Game Range, 1958-1963.

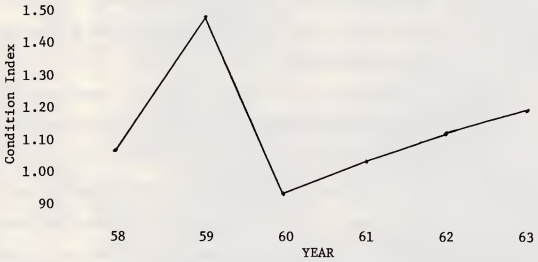

Figure 8. Condition trends of bluebunch wheatgrass on the Sun River Game Range, 1958-1963.

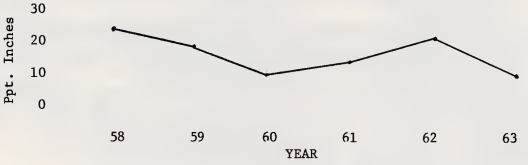

Figure 9. Precipitation trends, 1958-1963, Sun River Game Range.

THE POPULATION

Preliminary Statement

Throughout this study general population information was gathered coincidental with the data on the use of vegetative types. Early phases of the investigation from 1960-1963 were mainly investigations to clarify range relationships and determine if poor nutrition was causing low calf production. For reasons given in the discussion it appeared that winter range condition was not the major limiting factor in this elk herd. Population data recorded during the range investigation phase along with thoughts of other writers (Casagranda 1958, and Janson 1961) indicated that the Sun River Game Preserve and the harvest conditions cuased by it might be partly responsible for low production. Since data were gathered and the working hypothesis developed on a year-by-year basis but presented in sections by subject, a preliminary statement will clarify the theme of the study for the reader so that he will have some idea as to where the data are leading.

Comparisons of checking station records and winter calf:cow ratios indicate that calf production both in the harvest and in the winter classifications fluctuated according to size of the harvest. Janson (1961) stated that segments of the herd harvested early in the season are more productive than those harvested later in the season. Those harvested later are those that tend to stay inside the Game Preserve longer and hence, are more lightly harvested. Checking station records also indicate a higher calf

production in the area south of the Sun River. The southern area receives about twice the hunting pressure as the northern area. From prior information, along with data gathered during the present investigation the following working hypothesis was postulated:

1. Differential rates of harvests existed between populations inside the Sun River Game Preserve and outside the Sun River Game Preserve, and also between animals in the northern portion of the area and the southern portion of the area.

2. Those segments of the population that are harvested at the highest average rate are the most productive and those harvested at the lowest rate are stabilized with a low rate of mortality and low natality.

The population phase of the investigation was designed to answer the three following questions:

1. Is the elk herd made up of separate, independent units, separated by habitual use of different range areas?

2. If so, is there a difference in the sex and age structure among these populations and what is the effect of these differences upon the herd as a whole?

3. What would each separate population contribute to the harvest? Are some of the units within the herd being excessively exploited while others are being underharvested, if so what is the effect on the sex and age ratios of these populations and on the herd as a whole?

To answer these questions, it was necessary to have marked animals that could be followed through the annual cycle and their

seasonal ranging and migration habits observed, as well as relationships with other animals. Accordingly, 209 elk were trapped and individually neck-banded during the winters of 1963-64, 1964-65. Trapping procedures were essentially those of using helicopters to drive elk into traps as explained by Howe (1963). The marking procedure and general effectiveness of the program have been previously published (Knight 1966b). The site of the drive trap was in the northern part of the area and sampled only the elk that migrated through there. Choice of a trap site was influenced by intention to obtain the largest and best distributed sample of the northern part of the herd and by the physiographic requirements of the trapping procedure. Elk were trapped on six different dates: December 19, 1963; January 7 and 8, 1964; February 12, 1964; December 19, 1965; and January 10, 1965. Thirty additional elk were trapped in bait-type traps on the Sun River Game Range. Animals were re-observed and identified when encountered on observation routes traveled by helicopter, horseback, on foot, and by four-wheel-drive vehicle where possible.

The remainder of this paper will present data that are applicable to the entire population or cannot be broken down for separate groups, and then will examine the possibilities of distinct population segments. Populations are discussed primarily in relation to winter and summer distributions since these are assumed to be the two extremes of the annual migration pattern. Spring and fall, or intermediate, ranges covered approximately the same areas and were considered to be common to all of the elk ranging

in the North Fork of the Sun River. Migration patterns for summer and winter ranges are considered in relation to the intermediate ranges.

Herd Size

The actual size of the entire herd during any one year is a source of constant controversy between the Fish and Game Department and the sportsmen. Approximations of herd size are subject not only to population fluctuations but also to varying conditions accompanying the counts or to estimating procedures. Actual aerial counts in recent years have ranged from a high of 3,516 in 1957 to a low of 1,289 in 1964. Lovaas *et al.* (1966) have discussed the difficulties of elk counting from the air using this herd as one of their examples. They explained the need for rigorous winter conditions when trying to obtain accurate counts.

The reason for making a herd count is to assess the population trends. To do this correctly it is imperative to have some way of assessing the accuracy of the count. A method whereby a quantitative value can be placed on a winter is a much more valuable tool than the commonly used adjectives of mild, moderate and severe.

Weather Evaluation. - Picton and Janson (1961) have devised a method for assigning quantitative values to winter conditions. They used standard weather station data to compute a numerical index for each year as follows: The index is computed from the daily maximum temperatures, snow depth, and wind notations. The

temperature of 32° F is the breaking point. The number of degrees below 32° F are regarded as positive winter points and the degrees 32° F and above are regarded as negative winter points. Snow on the ground is treated as a multiplier of low temperature effects. The snow depth in inches is multiplied by the positive temperature values.

Wind is also treated as a multiplier of low temperature effects. Since wind velocities are usually not measured at weather observer stations, the wind notation was taken only when there was a check in the high wind column on the station data sheet. On any day when a high wind was noted, the index value for that day was multiplied by two. In case there was snow on the ground and a temperature of 32° F or above, the number of inches of snow was subtracted from the negative degree values. High winds were not considered in relation to negative winter points.

The points for each day are added to points previously accumulated throughout the winter period which in this case was considered from November 15 to March 31. In some cases, the effects of cold weather periods are erased by a period of mild weather following them. Whenever ten or more days of cold weather were followed by ten or more days of mild weather, a correction was made as follows: The number of positive points accumulated in the cold snap, in other words, the number of days of positive points between periods of warm weather is divided by the days of mild weather. This value was then substituted for the cold snap value in computing the cumulative total.

Counts. - Using data from the Gibson Dam Cooperative Weather Observation Station, an index was computed for each winter. Winter index values compared to elk counts for the years 1955 through 1966 are given in Figure 10. Counting techniques were those employed by Lovaas *et al.* (1966) with the exception that helicopters were not used from 1955 through 1962.

The number of elk counted appears to bear a general relationship to the severity of the winter. Time of day, individual observers, atmospheric conditions on the day of the count, and probable unknown factors all contribute to variance between counts.

The maximum numbers counted during both severe and mild winters show a definite downward trend since 1957. The reason for this decline is uncertain. Although calf production is low, the checked harvests since 1960 have not been large enough to take the annual crop. Known winter kill is also low, usually less than 10 animals each winter.

Part of the downward trend might have resulted from more dispersed ranging habits in recent years. The counts are most reliable when large percentages of the elk counted are out on the grassland areas of the Sun River Game Range. Lovaas *et al.* (1966) report that during seven winters when over 3,000 elk were counted, an average of 76 percent were on the Sun River Game Range. On six counts where less than 3,000 elk were counted, an average of only 57 percent were on the Sun River Game Range. Counts from 1960 through 1965 have not included any instance where the percentage of elk on the Game Range exceeded 66 percent. They (Lovaas

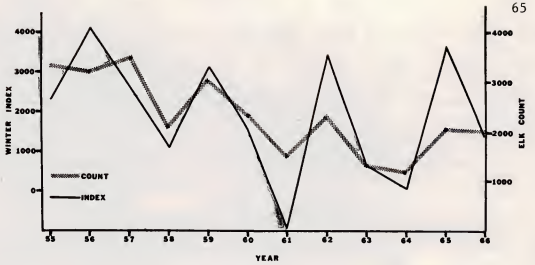

Figure 10. Trends in the elk population as reflected by winter aerial counts compared with severity of winters.

et al.) also report that during the 1964 count, only 17 percent of 152 tags known to be in the population at the time of the count were recorded during the count, leaving a substantial number of elk unsighted. These observations indicated that the population decline has probably not been as severe as shown in Figure 10.

Grouping Characteristics

Elk are generally thought of as a highly gregarious species. Darling (1964: 33) in discussing a closely related species, the red deer (*Cervus elaphus*), states that they appear "to have reached the highest development of sociality in the grazing herd". This idea of a close group sociality has apparently carried over to discussions of American elk. Murie (1956: 261) mentions the basic herding habit with a general discussion of change of group sizes at different seasons of the year. Several other authors (Altman 1956a, b, Martinka 1965, Schwartz and Mitchell 1945), mention the grouping characteristics of elk with respect to seasons and/or sex.

The concept of elk occurring in groups necessitates an analysis of the grouping habit under varying environmental conditions. Elk are commonly managed or described by groups, usually as a herd or as smaller groups or segments within the herd. Accordingly, the size and composition of groups were analyzed for both seasonal changes and changes with vegetative type throughout this investigation.

Monthly Group Sizes

There is a definite difference in grouping characteristics between groups containing cows and calves and those containing bulls only (Figure 11, Table 11). Cow and calf groups were consistently larger than bull groups. Small groups containing between two and ten animals were most common throughout the year for both sexes.

Cow-calf groups reached the greatest mean size during January and declined slightly during February and March. Distribution of group sizes was about the same for all winter months. Largest annual group sizes were also observed in winter. During spring when the migration and calving season was in progress, a sharp decrease in mean group size occurred with high percentages of observations on small groups.

The greatest percentage of single cows was observed during June. Group size increased in July when maximum numbers were on the summer range, declined during August, and reached a low for the year during September when many had left the open areas of the summer range and were returning to fall ranges. Small groups of two to ten animals were observed most frequently during September. There did not appear to be a grouping for migration as observed by Murie (1956).

Group sizes increased during the fall in October and November and decreased slightly in December before reaching a high for the year in January. Mean group sizes from June through October were smaller than observed by Cole (1963) in Grand Teton National Park

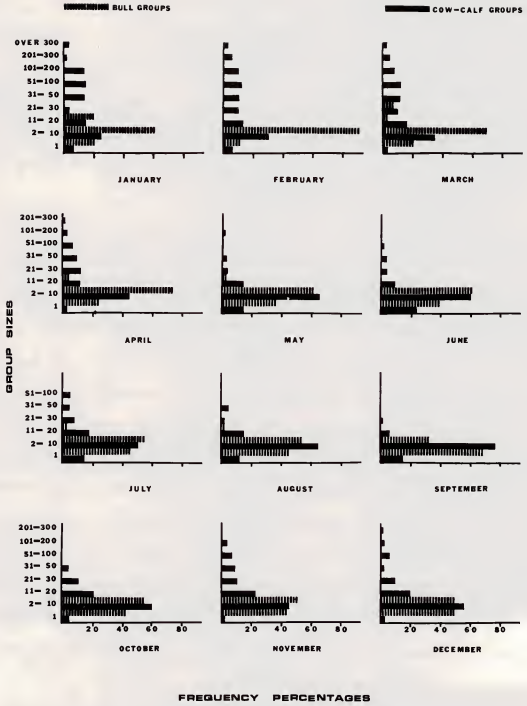

Figure 11. Observed frequency of occurrence of various group sizes throughout the year. (Frequency percentage) is expressed as percentage of total observations for each month.

TABLE 11. MEAN AND MAXIMUM OBSERVED GROUP SIZE OF COW-CALF AND BULL GROUPS, EACH MONTH.

Month	Cow-Calf Groups 1/		Bull Groups 2/	
	Mean	Maximum 3/	Mean	Maximum
January	48	646	2	6
February	41	352	4	6
March	41	725	5	27
April	19	229	3	11
May	8	181	3	11
June	6	41	2	9
July	10	96	2	20
August	6	50	2	15
September	3	20	1	2
October	8	37	2	4
November	20	117	2	3
December	18	278	6	7

1/ Groups containing cows and calves, may also have some yearling and 2-year old bulls.

2/ Groups containing only bulls over 2 years old.

3/ Includes only groups classified according to sex and age composition. Two groups were estimated at figures higher than those given in the table. One of 800 in February and one of 1,000 in April. Both were observed immediately after heavy snowfall.

but the trends were essentially the same with small groups in June increasing in size in July, and reaching a low point in September and increasing again through October.

Bull groups were smaller than those containing cows and calves with the mean observed group size never exceeding six in any month. The yearly trend in mean group size for bulls did not follow that observed in the cows. While cow groups fluctuated widely in size between a mean of three in September and forty-eight in January, the mean for bull groups fluctuated only between a low of one in September and a high of six in December. The mean group size of two was that most commonly observed, occurring six months out of the year and in every season. The highest mean group sizes for bulls occurred during migration in March when bulls were leaving the winter range and again in December when they were migrating to the winter range. The lowest mean group size for bulls occurred at the peak of the breeding in September.

Group Sizes by Vegetative Type

Some of the observed changes in group sizes with seasons may be connected with changes in habitat use patterns. Comparatively high group sizes were recorded during the winter months when large percentages of animals were observed on the open grass and bottom types (Table 9) where the largest mean group sizes were noted when compared by vegetative types (Table 12). Maximum group sizes of cow-calf groups for all months were also observed on open grass types.

TABLE 12. GROUPING CHARACTERISTICS OF ELK BY VEGETATIVE TYPE.

Vegetative Type	Mean Group Size	
	Cow-Calf Groups	Bull Groups
Grass	25	3
Bottom	17	6
Forb	9	3
Limber Pine	15	5
Lodgepole Pine	6	1
Aspen	7	2
Lodgepole-Aspen	10	2
Douglas Fir	10	2
Burn	10	2
Beargrass	10	2
Spruce Fir	8	2
Park	7	2

High group sizes on the more open vegetative types could be partially ascribed to the better conditions for observation on those types but most of the change of group size should be attributed to the change in seasonal changes of the habits of the animals. Mean group sizes dropped during April, May and June when a majority of the elk were observed on the open grassland types. So there is a break-up of animals into smaller groups during spring migration and calving independent of vegetative type or observational bias.

Observed group sizes were actually larger in some of the timbered types compared to some of the open types. Limber pine, lodgepole-aspen and Douglas fir all had observed group sizes larger than the open forb type. High figures for limber pine were probably due to the time of year when this type was used to the greatest extent. Most of the observed use of limber pine was associated with higher group sizes of the winter and early spring. Lowest group sizes were observed in lodgepole pine, possibly because it offers the poorest visibility or perhaps because most of the observed use of this type was during the fall when most of the group sizes were quite low. Smaller group sizes on the forb type are likewise ascribed to the summer grouping habits of the elk rather than a change of vegetative types.

Mean group size on all types were higher than found by Picton (1960) for the summer months when he found a mean group size of 7.2 in open areas and 2.5 in timbered areas. This may have been due to the difference in methods, Picton using ground observations compared to predominantly aerial observations in this in-

vestigation. Maximum observed group size on the summer range was lower at 96 in this study (Table 11) than the maximum group of 119 observed by Picton, and considerably lower than summer group sizes mentioned by Murie (1951: 261) at 400 and Altman (1956) at 1,000.

No pattern of increasing froup size with either increasing snow depths or decreasing temperatures was observed. Average group sizes were larger during snow conditions than during the absence of snow. The greatest mean size was reached when snow depths ranged from 7 to 12 inches but declined with deeper snow. Highest group sizes were observed between temperatures -10° F to +10° F and declined with both higher and lower temperatures. Snow depths greater than 12 inches are rare on most of the Sun River winter range and few elk were observed under these conditions. Elk observations under temperature conditions below -10° F were also a small sample.

Group Constancy

Group constancy is used here to describe the tendency for a particular group of individuals to stay together. The term "social" has been avoided since it implies reactions or responses which are conceivably present in a group that has little or no constancy. Etkin (1964) defines a social group as one whose members stay together as a result of their social responses to each other rather than any other factor in the environment. Groups which owe their existance to attractive factors in the environment rather than

social responses are called aggregations. A tendency toward constancy or cohesiveness among a particular group of animals throughout the year or for a season would imply a social grouping. If groups of animals tend to break up and reassemble with different combinations of individuals they would more properly be called aggregations.

It should be emphasized that a wide range of social responses including a dominance heriarchy may still be present in an aggregation. Behavioral phenomena such as agnostic behavior, submissiveness, and cominance can exist within a temporary grouping as well as within more permanent groups.

At the beginning of this investigation, it was assumed that groups of elk were characterized by a fairly high degree of constancy. Small summer population groups, which were occasionally broken into smaller, presumably, family groups, were believed to be the basic unique segments within the population. These small groups were thought to migrate as a group as described by Altman (1956a) and to form aggregations of various sizes on the intermediate and winter ranges but still retain their integrity or cohesiveness as a small group. This assumption is more or less implied throughout elk literature where groups, bands, or segments with the same ranging area and/or migration habits are mentioned.

The idea of group constancy among elk probably stemmed largely from the work of Darling (1964) on red deer in Scotland. He described a social system consisting of a matriarchy founded

on the family unit and believed that groups retained their social integrity although often forming larger temporary groups. He also mentioned that the outstanding feature of the hind group is its cohesion, which is taken to mean the same as group constancy in this report.

Altman (1952) discussed the social behavior of elk in Wyoming and indicated that groups of elk tend to retain the same individuals but often broke into sub-groups. She reported a definite "group feeling" because after disturbance a group's components re-form into the same herd. This intimates a certain amount of group constancy, but without marked animals it would be difficult to be sure the same individuals were re-forming into the same group. Altman (1960) also mentions a group cohesion among female groups.

In 1964, after several months of observation of marked individuals, it appeared best to re-examine the assumption of group constancy. Tagged individuals which were found together one day were found with other tagged individuals on other days. This did not fit with the group constancy hypothesis. By the end of this investigation in 1965, there was little or no evidence of group constancy. With only a few exceptions, no two individuals other than a cow and her current calf were closely associated for more than several days.

Since the idea of absence of group constancy seems to be a departure from previous thinking on the subject, an attempt was made to express this quantitatively. This was done by calculating

a coefficient of association between all combinations of any two animals that were seen to associate with each other at least once. A lack of association between any two animals precludes the possibility of association between groups of more than two individuals

Initially, a table was constructed for each tagged animal observed during each of seven seasonal observation periods (winter through fall, 1964 and winter through summer, 1965). All tags ever observed to be in association with this tag were listed along with the frequency of assocation. This listing was accomplished with the aid of an IBM 360/30 computer.

The degree of association between any two animals was expressed as the probability of their occurring together by Cole's (1949) formula for the coefficient of association:

$$\frac{2\,ab}{A + B}$$

where A is the number of times animal A was observed throughout the season, B is the number of times the animal B was observed throughout the season and ab is the number of times that animals A and B were observed to be together throughout the season. Using this formula, a value of 1 would indicate perfect association or the probability that A and B would occur together 100 percent of the time. Theoretically, the probability should vary linearly from 0 to 1. In this case, the probability will never decrease to 0 since the method by which the pairs were chosen dictates that ab must always be at least 1.

Mean values for all coefficients of assocation calculated for

each of seven seasonal periods are listed in Table 13. These values express the probability of two animals once associated being associated again during each seasonal period. Associations between cows and young-of-the-year are not considered since no combinations of marked calves and mothers were available. The mean coefficient of association never exceeds .50, indicating that there is no great attraction or association between particular animals within the population. Summaries of all observed associations for 12 animals relocated 20 or more times are given in Appendix A.

Some of the animals did have a high degree of association for one seasonal period. Perfect associations (a coefficient of 1.0) were recorded in the spring and fall seasons of 1964 and during the winter and summer seasons of 1965. Small percentages of animals with high coefficients of association (values between .76 and .99) were recorded during all seasons. All of the animals with high coefficients of association during a season were checked for further association by comparing their associations in the following seasons. High coefficients of association observed during the summer of 1965 season were compared with the previous seasons since data were not available for the following season.

Of 14 pairs of animals with perfect associations, only one pair were observed together in the next season, and this pair was not associated at all in the next season thereafter. Of the associations with values between 76 and 99, 71 percent were not

TABLE 13. MEAN SEASONAL COEFFICIENTS OF ASSOCIATION AND PERCENTAGES OF COEFFICIENTS IN FIVE FREQUENCY CLASSES FOR SEVEN SEASONAL PERIODS.

Year	Season	Mean Coefficient Of Assocation	Number Of Associations	Percentages in Frequency Classes				
				.0-.25	.26-.50	.51-.75	.76-.99	1.00
1964	Winter	.34	312	39	52	8	1	
	Spring	.35	865	35	57	7	1	* 1/
	Summer	.47	86	7	77	12	4	
	Fall	.41	509	11	73	15	1	*
1965	Winter	.39	2488	34	46	16	4	*
	Spring	.29	2168	53	43	4	*	
	Summer	.39	436	20	68	8	3	1

1/ Less than 1 percent of association calculated fell into this class.

associated at all in the following or previous seasons. Of the 29 percent observed to be associated in the previous or following season the coefficient of association was .32 and only one of these associations was observed together in the next season.

It is doubtful that individual elk of the Sun River herd can be grouped into sub units of any size that will have a lasting association throughout the year. A similar conclusion has been reached by Schloeth (1961) for red deer in Switzerland. His results which were also based on observations of individually marked animals indicated that constancy of herds could not be anywhere established. Craighead and Shoesmith (1966), using individually marked animals in Yellowstone Park also observed a low degree of association between specific individuals throughout the year except during the rutting season. They also state:

> "Even when an elk association occurs, it is relatively short termed."

These results indicate that groups of elk occurring at any one observation would be best described as aggregations rather than social groups as defined by Etkin (1964). An attractive environmental factor might originate the aggregations but they are undoubtedly strengthened by gregariousness.

The lack of group constancy makes any management plan directed toward manipulation of discrete groups impossible. Groups of animals found on a particular winter or summer range area could not be expected to remain stable. Constancy of groups between seasons and during migrations would also be unstable, and hunting seasons designed to harvest elk from a particular summer range or

the intermediate range are not possible. Manipulation of populations using specific range areas will have to be implemented on the specific areas at the time of use.

The Breeding Season

The breeding season for elk has received much attention in the popular literature. Most descriptions give undue attention to the more spectacular and rare events and contain large amounts of anthropomorphic speculation. Quantitative information on breeding habits is very difficult to obtain and almost non-existant in technical literature. Several good qualitative descriptions of the breeding season have been given by various authors, especially Murie (1956): 123) and Altman (1960).

In the Sun River breeding season begins in late August when some of the bulls begin to disperse and establish territories. Most are established on summer and transitional range, although one territorial bull with a harem was observed on the winter range. The peak of the breeding activity was reached in September as evidenced by the amount of bugling and occurrence of single bulls (Figure 11). Other investigators have also reported September to be the period of most intensive breeding activity (Murie 1956, Altman 1960, Schwartz and Mitchell 1945).

Bugling was not as common throughout the duration of this study as intimated by other authors for other areas. In all cases where a bugling bull was observed, the bull was either on a territory but without cows in evidence or apparently without a territory.

Throughout this study no bull on a territory and with cows was observed to bugle. Bulls with harems appeared to ignore all breeding activities taking place outside of what was assumed to be their territories. When another bull invaded the territory of a bull with a harem, the harem bull then took steps to chase the newcomer from the territory. All encounters between bulls during the breeding season followed the same pattern: The intruding bull and the harem bull would confront each other and appear to size each other up after which the intruding bull would turn and leave. Actual fights between bulls are apparently vary rare. This has also been reported by Murie (1956) and Schwartz and Mitchell (1945). No fights between bulls during the breeding season were observed during this study.

The reactions of territorial bulls to intruders other than bull elk appeared governed by the presence or absence of a harem. The typical reaction of a territorial bull without a harem was to stand his ground against an intruder. This included the investigator whether on foot, horseback or traveling in a helicopter. The reaction of territorial bulls without harems to the helicopter was particularly interesting: The typical reaction was to ignore it. Several bulls approached by the helicopter acted as though it did not exist until the "downwash" from the machine showed a visible blowing effect on the surrounding vegetation and the bull itself, at which time the bull would move off but not panic.

In contrast, bulls with harems typically followed the lead of the cows and calves. If the cows and calves resorted to flight,

the bull followed, but if the harem was not frightened, the bull would stand his ground against man, horse or helicopter as described for territorial bulls without harems.

Harem Sizes

All observed harems were associated with bulls 2½ years old and older. No yearling bulls were observed to take part in the rut. Most of the breeding is apparently accomplished by the older bulls (over 2½ years). If a raghorn bull (2½ years old) is actively breeding he is normally associated with a single cow. Twelve of 16 raghorn bulls observed with harems were associated with only one cow, three were associated with two cows and one with three cows. Murie (1956: 128) reported that although raghorn bulls are sexually active and attempt to steal cows from older bulls, they do not hold harems. This may also be typical in the Sun River, since raghorns were commonly observed in the vicinity of harems held by older bulls; however, those associated with cows were usually observed in fairly dense timber types and away from the vicinity of the older bulls.

Older bulls usually were associated with larger harems. The average size of harems associated with bulls older than 2 years was five adult cows, and two calves. Sizes ranged from one cow and one calf up to 21 cows and six calves with four to five adult cows most common. Six of the 63 harems observed also included spike bulls which appear to be normally excluded from the harems by the territorial bull.

Harem sizes in the Sun River appeared to be smaller than those found by other investigators. Schwartz and Mitchell reported five to fifteen adult cows to be the most commonly observed harem size in the Roosevelt elk, Rush (1932) reported that harems average six adult cows in Yellowstone Park and Altman (1960) reported a common harem size of 10 to 15 cows with calves in Wyoming. The mean size of five in the Sun River area is the same as reported by West (1941) for the same area for the 1939 season.

Conception Dates

Twenty-five fetuses collected during this study were measured (crown-rump) and compared with a chart of crown-rump lengths plotted against age (Morrison *et al.* 1959). Ages of embryos were back-dated from their date of collection to approximate conception dates. The mean conception date was approximated at September 20 for the Sun River area. The earliest conception was approximated as August 22 and the latest at October 3.

The Sun River breeding season is apparently earlier than that for the National Bison Range and the Northern Yellowstone Herd. Morrison *et al.* (1959) reported average conception dates for the National Bison Range and Yellowstone Park as October 3 and October 6, respectively. Eighty percent of the conceptions approximated for the Sun River fell between September 20 and 30.

HARVEST

The Sun River elk harvest has been regulated by a quota system since 1955. Under this system a harvest goal is established and the season is left open until the desired number of animals have been taken. The season is closed on 48-hours notice when the quota is reached. From 1955 through 1958 the quota was established by the Game Manager for the District. Since 1959 the quota has been recommended by the Game Manager, but actually set by the Fish and Game Commission. The mean quota for the area from 1955 through 1958 was 625 animals per year. From 1959 until present the mean quota has been 364 animals. Quotas have varied from a low of 210 in 1964 to 800 in 1957.

Established quotas were reached or exceeded in all years except 1962 through 1965. In those years when the quota was not reached, the season was closed before the desired number of animals could be taken, usually due to a combination of adverse public opinion and poor hunting conditions.

The number of animals harvested during any given period of time was closely correlated with the weather conditions during that period. This is generally true where new snow assists the hunter in tracking and quiets his approach to the game, besides forcing animals into lower, more accessible areas in mountainous country.

In the Sun River area the hunters' reliance on the weather is intensified by the presence of the Sun River Game Preserve. The hunters depend upon severe weather conditions to drive the

elk from the Preserve and toward their winter ranges in the open area. The pattern of harvest is usually one where success is high in the first few days of the season followed by a quiet period until a fresh supply of elk are driven out of the Preserve. The situation is similar to that occurring in the Gallatin elk herd where hunters are dependent on elk migrating out of Yellowstone Park (Peek, *et al.* 1967).

The relationship between harvests and weather conditions is illustrated in Figure 12. The weather index was compiled in the same manner as for the winter index except that negative values were not considered. The total number of positive weather points were accumulated from the beginning of hunting season until the end. These were then divided by the number of days in the hunting season to give an average index point per day. The harvest is also expressed as average number of elk taken per day, or total number of elk taken divided by the number of days in the hunting season.

Figure 12 indicates fairly close correlation between the index points per day and the elk per day with the exception of 1959. Weather conditions in 1959 were severe enough to limit the hunters as well as force the elk out of the Preserve. A severe storm midway through the hunting season resulted in 20 inches of snow and 27 degree below zero temperatures. Personal communication with personnel who were in the area at the time indicates that most of the hunters in the area were trying to get out rather than hunting elk.

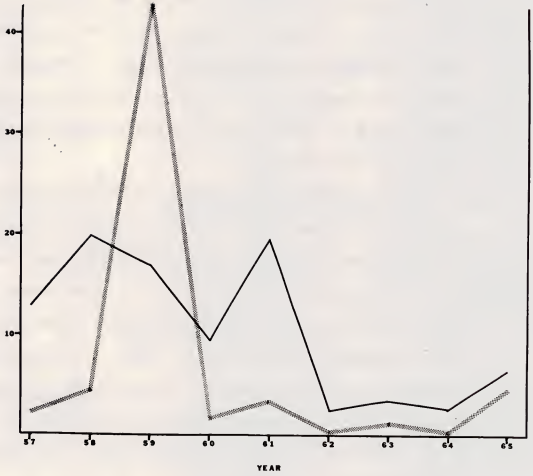

Figure 12. Average elk killed per day (solid line) and average weather points per day (stippled line) for hunting seasons from 1957 through 1965.

A correlation coefficient (r) was computed to express the degree of relationship between elk per day and weather index points per day. Using standard linear correlation methods ($y = a + bx$) and excluding 1959, gave a value of $r = 0.9058$. Comparison with tables of distribution of r (Dixon and Massey 1957) shows this to be significant at the .99 level of significance ($r_{(6)} = 0.9058\ 0.811_{99}$).

A significant drop in the total number of elk taken and elk taken per day beginning in 1962 may reflect a greater dependency on elk being forced out of the Preserve by weather and a corresponding drop in the number of elk initially available outside of the Preserve early in the hunting season.

A summary of the harvests results from 1957 through 1965 is given in Table 14. Harvest figures for the norther portion of the area including all of the area north of the Sun River (Figure 1) and the southern portion including all of the area south of the Sun River are separated, since intensity of harvest is different for each.

Checking station records prior to 1957 are not included because locations of kills were not recorded. Inspection of the table shows that roughly two-thirds of the annual harvest has been taken from the southern portion throughout the period considered, although the two areas are about the same size. This is partially due to different accessibility in the two areas and partially due to different lengths of seasons. The southern portion of the area is accessible by a road up through Ford Creek

TABLE 14. SUMMARY OF ELK HARVEST, 1957-1965.

Year	Quota	North					South				
		Cow	Calf	Ratio	Bull	Total	Cow	Calf	Ratio	Bull	Total
1957	800	45	32	71	53	130	342	116	34	218	676
1958	600	107	29	27	71	207	187	72	39	184	443
1959	450	110	30	27	73	213	169	63	37	114	346
1960	400	94	30	32	49	173	101	40	40	88	229
1961	450	71	26	37	44	141	144	72	50	189	405
1962	350	11	10	91	28	49	34	22	65	39	95
1963	250	19	15	79	27	61	23	20	84	17	60
1964	210	15	5	33	23	43	23	9	39	25	57
1965	400	66	17	26	109	192	34	12	35	55	101
		538	194	36	477	1,223	1,057	426	40	929	2,412

Cow:Bull Ratio = 53:47

and down to the Forks of Straight Creek in the South Fork (Figure 1) and another road connecting Willow Creek with Beaver Creek. This enables hunters to drive to the edge of the Preserve in the southern area and also ready access for weekend hunters. The northern portion is accessible by road only to Gibson Reservoir which leaves a distance of approximately 8½ miles by trail to the head of the reservoir and the Game Preserve. One other road partially follows Hannon Gulch and another crosses the eastern portion of the area from the Sun River to the Teton River.

The northern area was closed to hunting on a definite date from 1945 through 1960. This meant that if the harvest was not reached by November 15 each year the remainder of the harvest was taken from the southern portion. Beginning in 1960 the length of the hunting season was the same in both areas and in 1964 and 1965 the quota was set with the stipulation that only one-third of the quota would be taken from the southern portion and two-thirds to be taken from the northern portion. In 1964, it was decided to close the entire area at the end of the general statewide hunting season and re-open the northern portion after the elk had migrated from the Preserve, but adverse public opinion prevented the re-opening. In 1965 a quota of 100 was assigned to the southern portion with a quota of 300 to the northern portion, with the northern portion to be harvested on a permit basis after the close of the general season. This also proved unsatisfactory. Although the elk did migrate from the Preserve into the open area along the North Fork of the Sun River, they were still inaccessible

to hunters who did not have the necessary equipment to go into the Wildnerness Area.

Life Tables

Whenever possible, harvested animals were assigned age classes according to mandibular dentition (Ouimby and Gaab 1957) characteristics of the radius-ulna (Knight 1966a) or wear on the upper canines (Greer and Yeager 1967). Life tables have been constructed from assigned-age-animals taken in the 1961 through 1965 harvests. Separate tables are given for the northern and southern areas as well as males and females (Tables 15 and 18). Construction of the tables followed Quick (1963). Data were obtained from 201 females older than calves and 135 males older than yearlings.

Calves and yearling males are usually recognized at the checking station without resorting to an aging method. Because all of these animals were aged compared to only a sample of older animals use of uncorrected checking station figures would introduce a bias toward younger age classes. The ratio between the total number of cows harvested and the number of assigned age cows for each year was determined for each area and multiplied by the total number of calves listed for that area to give a corrected figure for claves. Yearling males were corrected by determining a ratio between all males older than yearlings that were harvested and males older than yearlings with assigned ages and multiplying by the number of yearling males.

Consequences of the heavier harvests in the South Fork was

evident in the harvest of cows but not for bulls. The life expectancies for all female age classes (e_x) was higher in the North Fork compared to the South Fork. Mean age for the female population was also higher in the North Fork than the South Fork. The half life (time required for one-half of the population to die) was about 4 years in the North and 3 years in the South. Life expectancies in both areas were considerably higher than shown by Harris (1963) for the White River herd in Colorado, which is apparently harvested at a much heavier rate. Mortality rates (q_x = number of animals dying per thousand in the age class) were higher in all age classes for the South. The low mortality rate for 3-year-old females in the North may reflect an inadequate sample.

The life tables for males were not indicative of the different harvest rates between the North and South areas. Tables for males in the northern area actually indicate a higher rate of exploitation than males from the southern area. Actual numbers of bull elk harvested are twice as high in the South Fork (Table 14) and the adult sex ratio in the harvest has been the same for both areas (53 females per 47 males). There is no explanation for the apparent heavier exploitation of bulls in the North Fork unless the actual sex ratio of the population was much lower than that in the South Fork. Field observations gave no indication of this.

Distribution of male age classes in the harvest appeared to differ slightly between the North Fork and the South Fork. Males in the South Fork had a higher mortality rate among calves while

TABLE 15. LIFE TABLE FOR FEMALE ELK IN NORTHERN SUN RIVER AREA, FROM HARVEST RECORDS, 1961-1965.

Age	Dead	d Dead/1,000	l Survivors	q_x	e_x
½*	15	180	1,000	180	4.65
1	9	108	820	131	4.56
2	9	108	712	152	4.17
3	3	37	604	61	3.83
4	11	133	567	235	3.05
5	6	73	434	168	2.83
6	6	73	361	202	2.30
7	8	96	288	338	1.75
8	4	48	192	250	1.38
9-15	10	120	144	833	.67
15+	2	24	24	1,000	.50
	83	1,000	0		

Mean Age - 4.89

Mean Age Over ½ - 5.84

* Corrected to conform to sample percentage of older females.

TABLE 16. LIFE TABLE FOR FEMALE ELK IN SOUTHERN SUN RIVER AREA, FROM HARVEST RECORDS, 1961-1965.

Age	Dead	d Dead/1,000	l Survivors	q_x	e_x
½*	32	195	1,000	195	3.47
1	29	176	805	219	3.19
2	22	133	629	211	2.94
3	16	97	496	196	2.60
4	23	139	399	348	2.11
5	13	79	260	304	1.96
6	12	73	181	403	1.60
7	8	48	108	444	1.33
8	5	30	60	500	1.00
9-15	5	30	30	1,000	.50
	165				

Mean Age - 3.51

Mean Age Over ½ = 4.23

* Corrected to conform to sample percentages of older females.

TABLE 17. LIFE TABLE FOR MALE ELK IN NORTHERN SUN RIVER AREA, FROM HARVEST RECORDS, 1961-1965.

Age	Dead	d Dead/1,000	l Survivors	q_x	e_x
½*	19	190	1,000	190	2.36
1*	33	330	810	407	1.80
2	30	300	480	625	1.69
3	2	20	180	111	2.67
4	5	50	160	313	1.94
5	4	40	110	364	1.59
6	4	40	70	571	1.21
7	1	10	30	333	1.17
8	2	20	20	1,000	.50
	100				

Mean Age - 2.36

Mean Age Over ½ - 2.56

* Corrected to conform to sample percentage of older males.

TABLE 18. LIFE TABLE FOR MALE ELK IN SOUTHERN SUN RIVER AREA, FROM HARVEST RECORDS, 1961-1965.

Age	Dead	d Dead/1,000	l Survivors	q_x	e_x
½*	43	275	1,000	275	2.52
1*	27	172	725	237	2.28
2	39	248	553	448	1.83
3	18	115	305	377	1.92
4	12	76	190	400	1.77
5	8	51	114	447	1.62
6	4	25	63	397	1.52
7	2	13	38	342	1.18
8	4	25	25	1,000	.50
	157				

Mean Age - 2.52

Mean Age Over ½ - 3.28

* Corrected to conform to sample percentage of older males.

the rates for yearling and 2-year-old males were much higher in the North.

Quick (1963) has shown that life tables taken from a harvest are not necessarily a valid description of the population. This qualification is probably applicable to the Sun River area where parts of the population inside the Game Preserve are not subjected to the same hunting pressures as those outside. Part of the herd normally ranged outside of the Sun River Game Preserve, remained there during the hunting season and probably was harvested at a fairly heavy rate. The rest of the population and probably the greatest part of it, normally ranged inside the Game Preserve in the summer and fall seasons and was harvested only when heavy weather in the fall forced them into areas open to hunting. Summer tag relocations made by Picton (1960a) as well as summer and fall relocations during this study found most of the tagged animals inside the Sun River Game Preserve.

Both the northern and southern areas and both sexes show younger populations than indicated by Picton (1961) using tag returns. Picton's tables are probably more representative of the population inside the Game Preserve than the life tables given here which are probably more descriptive of that portion of the population which is normally harvested.

Forty-four returns from elk tagged in the North Fork during the present study also indicated a light harvest on tagged animals. Two tagged animals, a yearling and a 2-year-old male, were taken in the 1964 season, the lowest harvest in recent years. This

was only 1.4 percent of the neckbanded animals of the population. Fourteen neckbanded animals were killed in the 1965 season which was characterized by more severe weather than 1964 but still required a re-opening of the season to approach the quota. This was 7.7 percent of tagged animals in the population at the time. At least eight of the tags returned in 1965 were from elk harvested after the season was re-opened. The 1966 season was characterized by more severe weather than any of the previous seasons and the largest harvest (417) since 1961. Twenty-eight tags (16.7 percent of the tags available) were taken in 1966. Fourteen of the tagged animals were killed during the extended season. These data indicate that tagged animals were more likely to be killed later in the seasons and probably represented the Preserve population.

Calf:Cow Ratios in the Harvest

That portion of the herd which normally ranged outside of the Game Preserve and subjected to heavier hunting pressure appeared to be more productive than that portion ranging inside the Game Preserve. Picton and Knight (1961) stated that the calf per cow ratio in the early part of the harvest was higher than that later in the season suggesting, that productivity of elk summering outside of the Preserve is greater than those inside. This can also be expressed as a ratio of the total animals in the harvest. As the total number of cows in the harvest increased the ratio of calves to cows decreased. This relationship is shown in Figure 13 for the years 1957 through 1965. The figures clearly show the in-

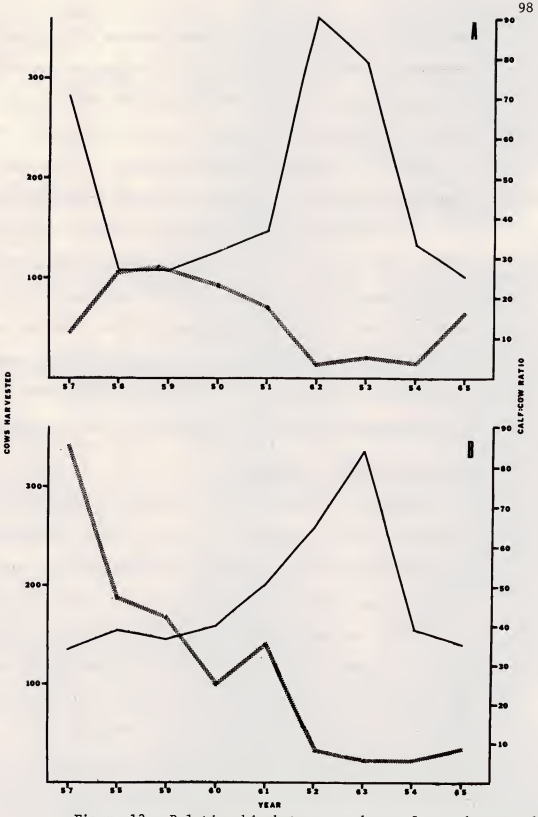

Figure 13. Relationship between numbers of cows harvested (stippled line) and the calf:cow ratio (solid line) for the North Fork (A) and South Fork (B).

verse relationship between cows harvested and production as expressed by calf:cow ratios. The chart for the North Fork is almost a mirror image of the two curves, and for the South Fork only 1961 shows a major deviation from this pattern.

Correlation coefficients were computed for each of the charts to measure the amount of agreement between the two lines. To measure the direct relationship between the inverse phenomena the correlation coefficient was computed on the number of cows in the harvest as shown in the graph and of the hundreds complement of the calf:cow ratio: i.e. each calf:cow ratio was subtracted from 100 and correlated against the number of cows harvested for that year. Standard linear correlation coefficients ($Y = a + b\ (100 - x)$) showed $r = 0.924$ in the North Fork and 0.821 in the South Fork. Comparison with tables of distribution of r (Dixon and Massey 1957) show the correlation to be significant at the 0.99 level of significant ($r_{(7)} \cdot 99 = 0.875$) for the North Fork and at the 0.95 level of significance ($r_{(7)} \cdot 95 = 0.754$) for the South Fork.

The inverse relationship between number of cows harvested and calf:cow ratio is interpreted to indicate a higher productivity in the population outside the Preserve. During the years of a light cow harvest most of the animals are probably taken from animals outside of the Game Preserve, since the weather is not severe enough to force the Preserve animals into the open area. During years when the hunting season is characterized by severe weather more animals are driven out of the Game Preserve to make up a

greater percentage of the animals harvested and be reflected in the lower overall production.

The difference in productivity between the harvested population outside of the Game Preserve and the lightly harvested population inside the Game Preserve was also exemplified during the trapping operation on North Fork in 1963. During the 1963 hunting season, with its light harvest, the ratio of calves:cows in the harvest was fairly high at 79. Later during December, 1963, and January and February, 1964 when 143 elk were trapped and tagged on the North Fork the calf:cow ratio was very low at 18 calves per 100 cows. These animals trapped on the North Fork were believed to be part of the population from the Preserve which comes out after the hunting season is normally over. Of 76 of these animals tagged in the 1963-64 winter which were subsequently associated with summer ranges, 57 or 75 percent of them were associated with summering areas within the Sun River Game Preserve and another 13 or 17 percent were associated with the population whose summer range is partially inside the Preserve and whose migratory routes take some of them inside the Preserve during hunting season. Calf:cow ratios were not recorded for the 1964-65 trapping season since most of the animals which were driven into the trap were able to break out and it was feared that those remaining may have given a biased calf:cow ratio.

Reproductive Tracts

Reproductive tracts were collected from cow elk during each hunting season from 1960 through 1965. Hunters were asked to turn in reproductive tracts and jaws from cow elk. Plastic bags were distributed at all checking stations for this purpose. A two-dollar reward was first offered for each reproductive tract and corrisponding mandible turned in to the checking station in 1961. A five-dollar reward was offered for reproductive tracts and mandibles during the 1962 through 1965 hunting seasons. No reward was offered in 1960.

The collection program was generally disappointing. Only 20 percent of the 601 cows harvested over the 6-year period were represented by reproductive tracts. Individual sample sizes ranged from 8 percent of the cow harvest in 1961 to 50 percent of the cow harvest in 1964.

Reproductive tracts were examined for evidence of pregnancy by examination of the uterus for embryonic material or examination of the ovaries for corpra lutea of pregnancy.

The average pregnancy rate for all years and age classes combined was 70 percent (Table 19). The lowest pregnancy rates were found in the yearling, 2-year-old, and over 15-year-old age classes. The pregnancy rate for 106 animals older than yearlings was 78 percent. The limited sample indicated a higher pregnancy rate in yearlings than has been found in some other Rocky Mountain herds. Kittams (1953) indicated a 5 percent pregnancy rate for yearlings in Yellowstone Park, and Greer (1966) found yearling pregnancy

TABLE 19. SUMMARY OF REPRODUCTIVE TRACT INFORMATION COLLECTED FROM HARVESTED ELK, 1960-1965.

Age	Number Collected	Percent Pregnant
1½	19	26
2½	14	64
3½	8	88
4½	17	71
5½	9	78
6½	8	88
7½	10	80
8½	7	100
9-15	8	75
Over 15	5	40
Unknown	20	90
Total	125	70

rates to vary between 4 and 28 percent over several years in Yellowstone Park.

The pregnancy rate of Sun River 2-year-olds is lower than that found in the Yellowstone Park herd as compared to the data of Kittams (1953) at 87 percent and Greer (1966) at 89 to 100 percent. Sun River pregnancy rates in the prime age group from 3 to 7 years averaged 79 percent compared to 91 to 100 percent in the same category observed by Greer (1966) in Yellowstone Park. Animals in the older age group showed a higher pregnancy rate of 86 percent while production dropped off in the very old with animals over 15 years showing only two out of five pregnant.

The sample size is not large enough to give a reliable sample for each year. Data presented in Table 20 compare the pregnancy rates found in yearly samples with the calf:cow ratios found in following years harvests. If the sample size were adequate, comparable trends should be evident for the yearly pregnancy rate and the calf production in the harvest each following year. The data indicate the exact opposite: The highest calf:cow ratio in the harvest followed the lowest pregnancy rate, and the lowest calf:cow ratio in the harvest followed the highest pregnancy rate.

TABLE 20. COMPARISONS OF PREGNANCY RATES WITH CALF:COW RATIOS IN THE FOLLOWING YEAR'S HARVEST.

Year	Cows Harvested	Sample Size	Percent Pregnant	Calf:Cow Ratio In Next Harvest
1960	195	26	77	46
1961	215	18	61	73
1962	45	17	59	83
1963	42	17	82	37
1964	38	19	84	30
1965	100	28	68	--

WINTER POPULATIONS

Much of the data on elk populations are normally gathered during the winter and early spring. This is the time of year when the elk are most concentrated, accessible and occur in the largest groups (see Figure 11). Most sex and age ratio surveys are made at this time (Riordan 1948, Banfield 1949, Hancock 1955) as well as censuses (Anderson 1958, Beuchner *et al.* 1951, Lovaas *et al.* 1966). Total numbers of observed elk in this investigation were much higher during the winter and early spring months than during summer and fall. Total numbers of elk observed during each season were: Winter, 26,373; Spring, 19,471; Summer, 5,397; Fall, 5,813. Of those observed in the spring, 11,384 were recorded during the month of April.

Production data for the Sun River elk herd are expressed as a ratio of calves:100 cows (calves observed/cows/observed x 100). These data are gathered by the classification counts on the winter ranges. Calves were spearated from cows largely on the basis of the relative length of the rostrum. The rostrum of the cow is much elongated in proportion to the size of the head when compared to that of the calf. This is best illustrated by Murie (1956, Plate 19) where the profile of a calf can be compared to that of a cow. Body size is usually a poor criteria since there is a wide variation among individuals.

Winter production figures for the Sun River herd for the years 1955 through 1960 are compared with production for other elk herds in Table 21. The Sun River herd was definitely below standard in

comparison with other elk herds. Only the Jackson Hole herd shows ratios as low as the Sun River among those compared in the table. A deficit of 20 calves per 100 cows exists between the Sun River herd and the next highest herd. This indicates that the herd is producing calves at a rate far below the potential for the species.

Concentration Areas

Winter population concentrations were observed on eight different areas totaling 55.6 square miles. Locations of the areas are outlined in Figure 14. Elk were not observed on all of the indicated areas during all of the winters during the investigation. Some of the areas were used fairly heavily every winter, while other areas were lightly used or not used at all during severe winters.

Areas 1 and 2 are two grassland plateaus at approximately 7,000 feet elevation. Together they comprise approximately 2.96 square miles of elk winter range. Although these areas are consistently used every winter, very few observations were made here since they are fairly inaccessible except by aerial survey. A total of 150 elk was counted on these two areas together during the 1965 elk count.

Area 3 is the Sun River Game Range and private land to the south of it. The area outlined in Figure 14 makes up an area of approximately 31.58 square miles. This is the largest winter concentration area both from the standpoint of size and elk numbers. Twelve hundred and eighty-six elk were counted in this

TABLE 21. AGE RATIOS IN THE SUN RIVER COMPARED WITH THOSE OF OTHER HERDS.

		Calf:Cow Ratio
a.	Sun River Year [1/]	
	1955	18
	1956	20
	1957	36
	1958	40
	1959	30
	1960 (Picton, 1960b)	32
b.	Other Herds	
	Judith River, Montana (Picton, 1960b)	55
	White River, Colorado (Harris, 1963)	66 [2/]
	Blackfoot, Montana (Hartkorn, 1962)	66
	Bitterroot, Montana (Janson, 1962)	52
	Cache, Utah (Hancock, 1955)	52
	Jackson Hole (Anderson, 1958)	30

1/ Data for 1955 through 1959 taken from Casagranda *et al.*, (1959).

2/ 1957-1962 average, pre-hunting season classification.

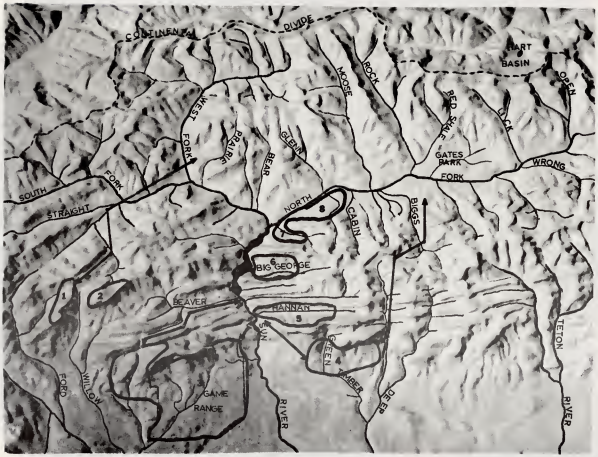

Figure 14, Boundaries of Winter Concentration Areas.

area during the 1965 elk count. The greatest body of winter population information comes from this area since it is also the most accessible.

Area 4 consists of approximately 5.45 square miles of privately owned land north of the Sun River. Observations were first made on this area in the winter of 1964 when marked animals were observed using the area. Fifty-four elk were counted on this area in the 1965 count.

Area 5, Hannan Gulch, furnishes approximately 5.24 square miles of winter range that was used intermittently. Elk concentrations in this area range from 0 to over 150. Thirteen elk were counted in this area during the 1965 elk count.

Area 6, Big George Gulch, was also used intermittently. During the study elk numbers in this area during the winter ranged from 0 to over 100. The area normally used by elk during the wintertime encompasses 2.55 square miles. Seventy-eight elk were counted in this area during the 1965 elk count.

Areas 7 and 8, Arsenic Creek and the North Fork Flats, are apparently used by the elk as a single winter range. Marked animals were observed to move back and forth between the two areas. These two areas encompass approximately 7.85 square miles and are used intermittently by a few to over 200 animals. A few animals appear to stay in Area 8 despite the severity of winter. Seventy-five elk were counted on these areas during the 1965 elk count.

Attachment to Winter Ranges

Elk exhibit a tendency to return to the same winter range each year. Brazda (1953) reported five marked individuals that returned to the same winter range each year. Allred (1950) indicated that attempts to establish new wintering areas by transplanting elk in Wyoming have been successful in that the elk transplanted on winter ranges returned to the same range area each year. Hancock (1955) reported that four animals tagged on winter range and transplanted to a nearby range returned to the original range the next winter.

During this investigation 193 marked elk were observed on winter ranges. Twelve of these had been tagged in the winter of 1963 and thus had the opportunity to be observed for three consecutive winters. One hundred and thirty had been tagged in the winter of 1964 and had the opportunity to be observed during two winters. Fifty-one were tagged during the winter of 1965 and therefore, could only be observed during one winter. Four of the animals tagged in 1963 on the Sun River Game Range were observed to use that area for three consecutive winters. One of these, had been trapped on the Sun River Game Range during a previous investigation (Picton 1960a) and, therefore, had used the area for at least four winters.

Sixty-eight of the animals tagged during the winter of 1964 were observed for two consecutive winters on the same winter range area. Forty-two of these were observed on the Sun River Game Range (Area 3, Figure 14). Twenty-one were observed to use Areas

7 and 8 for two consecutive winters. Four used Area 4 for two consecutive winters and one used Area 6 for two consecutive winters.

Five of the 42 animals observed using the Sun River Game Range for two consecutive winters had been previously trapped on this area. Three of the five had been trapped one previous winter and observed for two winters on this study making a total of 3 years that these animals used the same wintering area. Two animals had been trapped twice prior to this study and observed twice during this study making a total of 4 years on the same wintering area.

Since more animals are observed on the Sun River Game Range in severe than in mild winters, it is logical to assume that the severity of the winter affects the habitual use of winter ranges. Twelve individuals that used Areas 7 and 8 during the mild 1964 winter (Figure 10) were observed to move further down to Area 6 in the more severe 1965 winter. One animal observed to use Area 6 in 1964 moved down to Area 4 in 1965. These changes were not interpreted as changes in winter home range, but a pattern of moving further down the cnayon in response to a more severe winter.

Three animals changed winter ranges in a manner that could not be interpreted a response to winter conditions. Two cows that ranged in Area 3 in 1964 changed to Area 4 in 1965, and one cow changed from Area 3 in 1964 to Area 7 and 8 in 1965.

Population Characteristics

Sex and age classifications of animals observed on each wintering area from 1961 through 1965 are tabulated in Table 22. No ob-

servations were made in Areas 1 and 2 during 1961 or in Area 4 until 1964. Classifications of bulls are not representative because their habits of ranging in heavier cover types makes them much less observable than cows and calves. They are included in the table as a matter of interest but sex ratios are not computed from them.

There was a wide variation in calf:cow ratios among the different winter range areas. Area 3, which has by far the largest sample size, was most representative of the herd as a whole. Calf:cow ratios in Area 3 were consistently very close to the Calf:cow ratio for all the areas combined. Observed ratios in Areas 5 and 6 fluctuated widely during the years when used. Ratios in these areas were substantially higher than in other areas in 1961 but dropped to below average in 1964. They were again substantially higher than the average in 1965. Neither area appeared to be consistently used by a single group of elk.

Observed calf:cow ratios in Area 4 were higher than average during both years that it was covered by observation routes. It is not known how consistently the elk used this wintering range or for how long they have done so. Elk had been counted in this area prior to the investigation. Seventy-nine were reported for this area in the 1955 count and 29 in the 1958 count; but no elk were reported in counts during 1952, 1960 and 1961. The elk observed in this area were usually seen in heavier timber types than those on the Sun River Game Range and could have been easily missed in years when no elk were reported. Numbers of elk using this area may have increased recently since a landowner in the area reported

TABLE 22. POPULATION CLASSIFICATION ON WINTER RANGE AREAS BY YEAR, 1961-1965. [1/]

Year	Area	Classifications [2/] Bull	Spike	Cow	Calf	Ratio	Total
1961	3	97	82	1,982	603	30	2,764
	5	14	35	494	192	39	735
	6	1	3	52	23	44	79
	7&8	4	0	114	37	32	155
Total		116	120	2,642	855	32	3,733
1962	1&2	0	3	47	9	19	59
	3	16	154	3,281	1,071	33	4,522
	5	0	0	0	0		0
	6	0	0	0	0		0
	7&8	0	0	0	0		0 [3/]
Total		16	157	3,328	1,080	32	4,581
1963	1&2	0	3	60	21	35	84
	3	24	57	1,819	431	24	2,331
	5	0	0	4	0		0 [4/]
	6	0	0	0	0		0
	7&8	11	38	480	89	19	618
Total		35	98	2,363	541	23	3,037

TABLE 22. (Continued)

Year	Area	Classifications					
		Bull	Spike	Cow	Calf	Ratio	Total
1964	1&2	3	10	92	42	46	147
	3	35	53	3,821	958	25	4,867
	4	12	4	47	16	34	79
	5	0	1	45	6	13	52
	6	2	5	54	10	19	71
	7&8	11	16	104	8	8	139
Total		63	89	4,163	1,040	25	5,355
1965	1&2	2	14	88	37	42	141
	3	99	194	3,124	691	22	4,108
	4	29	24	77	22	28	152
	5	16	12	49	24	48	101
	6	22	21	169	63	37	275
	7&8	7	17	163	28	17	215
Total		175	282	3,670	865	24	4,992

1/ Areas not covered by observation routes during any year, not listed.

2/ Cumulative totals on all animals classified during the winter period.

3/ Some animals were present during the winter as evidenced by tracks and observations but were not counted or classified.

4/

heavier than usual damage to haystacks in 1964 and 1965.

With the exception of 1961, Areas 7 and 8 were consistently lower in calf production than the average for the herd. This would be expected if, as data from tagged animals indicated, these were animals moving from the Preserve after the hunting season. The observed ratio for 1964 is very low, even lower than the calf:cow ratio obtained from the 143 animals trapped there during December, 1963 and January and February, 1964 which was 18 calves per 100 cows.

Table 22 shows a sharp drop in the overall calf:cow ratio in 1963. The annual harvest had also dropped sharply in 1962 just prior to the 1963 winter (Table 14 and Figure 12). Table 14 shows that the 1960 and 1961 harvests, which were followed by calf:cow ratios of 32, were appreciably higher than the 1962, 1963 and 1964 harvests which were followed by calf:cow ratios approximately 10 percentage points lower.

The relationship between the harvest and the observed calf:cow ratio the following winter can be traced from the year 1954 through 1964. This relationship is easily seen in Figure 15 where each year's cow harvest is charted in relation to calf:cow ratios observed the following winter. These data indicate that an increased harvest of cows is followed by a corresponding increase in the calf:cow ratio during the winter immediately following. A correlation coefficient for the two lines in Figure 15 was computed using standard linear correlation methods ($y = a + b$). Correlation between the two lines was highly significant with the computed r equal to .926 ($r_{(9)}.9995 = 0.898$).

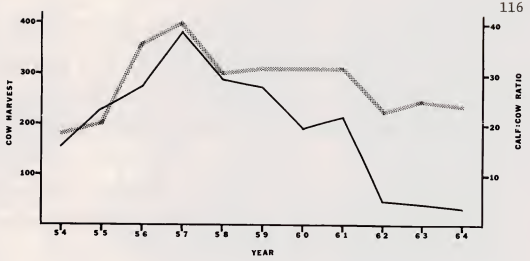

Figure 15. Number of cows harvested in each hunting season (solid line) compared with the observed calf:cow ratio (stippled line) the following winter.

This relationship between intensity of harvest and the following winter's calf:cow ratio complements the information shown in Figure 13 where the calf:cow ratio in the harvest was shown to be inversely proportional to the number of cows harvested. As the number of cows harvested increases the relative number of calves killed decreases. This results in a smaller percentage of non-productive cows observed the following winter and a higher observed ratio of calves to cows.

Population Estimates from Marked Animals

The presence of over 200 individually marked animals in the population in 1965 made it possible to make some rough population estimates other than the counts. It was not possible to utilize any of the commonly used proportionate indexes (Peterson Index, Lincoln Index, et.) because the tagged animals were not a random sample of the entire population, but rather from the northern portion of the herd. Also, separate estimates were required for the different wintering areas and there was not way of knowing the total number of tags present in any one area.

The method estimation used was based on the number of times an animal was re-observed during the winter. During any season several observations were made on each area. It was assumed that some animals were observed several times and contributed to the high cumulative totals shown in Table 22. The presence of individually marked animals made it possible to estimate the average number of times that any one animal was seen during the winter.

This information was applied as follows: All marked animals observed during the winter season were listed along with the number of times they were observed. The average number of times each animal was observed was obtained by adding up all relocations and dividing by the number of marked animals observed. The reciprocal of this relocation rate was then multiplied by the cumulative total of all animals observed on the area during the winter season to arrive at the estimate.

Three major assumptions that must be made in using this method were (1) the untagged animals were observed at the same rate as the tagged animals, (2) most of the animals using the area were observed at least once during the season, and (3) ingress and egress from an area were equal.

The estimates for Areas 3 through 8 are listed and compared with totals counted in each area in Table 23. No estimate was made for Areas 1 and 2 since only one tagged animal was seen there and only two observation trips were made. Estimated populations were very close to the counted populations in Areas 3 and 4 but considerably higher for Areas 5 through 8. It seems probable that the estimates for Areas 5 through 8 are more accurate than the counts because the estimation method appeared quite accurate for the two areas which are the most open where the elk were most easily counted. Elk can be easily missed on a single count in Areas 5 through 8 since they are within the mountain front where the rugged terrain and greater interspersion of cover types makes counting more difficult.

TABLE 23. COMPARISON OF ELK COUNT AND POPULATION ESTIMATES: CUMULATIVE COW-CALF RATIO AND COW-CALF RATIO FROM ESTIMATE IN 1965.

Area	Estimated Population	Counted Population	Relative Density[1/]	C/C Cum. Ratio	C/C Ratio From Est.
3	1,278	1,286	40	22	22
4	57	54	10	28	29
5	48	13	9	48	60
6	182	78	71	37	35
7&8	240	75	31	17	17
Total	1,805	1,506			
Areas Not Estimated		545			

1/ Elk per square mile from population estimate and area enclosed by boundaries in Figure 14.

As an additional check on the accuracy of the estimation method, a calf:cow ratio for each area was estimated in the same manner as the total population; i.e. the total number of cows were estimated and the total number of calves were estimated and the ratio computed from these two estimations. Calf:cow ratios from estimates were compared with calf:cow ratios from cumulative totals for 1965 from Table 22. The cumulative calf:cow ratio and the estimated calf:cow ratio were in very close agreement in all but Area 5. This plus the agreement between the counts on Areas 3 and 4 indicated that the estimation method was fairly accurate, and that the estimated population in Areas 5 through 8 were more accurate than the actual counts.

Winter Activity Centers

The concept of an annual home range is difficult to use and probably has little value in the case of a migratory population. Members of the Sun River elk herd may travel over 30 airline miles enroute from winter to summer range. Winter and summer ranges are the two end points of the migration and the elk spend a greater amount of time on them relative to the intermediate ranges which they cross enroute. The concept of summer and winter home ranges can be applied since the animals appear to be associated with definite areas for a period of 3 months or more during each of these seasons.

The extent of movement of tagged individuals was determined by using the concept of a center of activity (Harrison 1958, White 1964).

Relocations of each animal were plotted on a map and a geographical center (center of activity) was calculated by superimposing the relocations on a grid system as described by Hayne (1949). Standard diameters for each animal were then calculated by using Harrison's (1958) formula:

$$SD = \sqrt{\Sigma D^2/N}$$

where D is twice the distance from the center of activity to each relocation and N is the total number of relocations. The standard diameter describes the diameter of a circle with the center of activity as its center which contains 68.26 percent of all the relocations and presumably 68.26 percent of the animal's activity during the period considered.

Standard diameters were considered for each of the wintering ranges three through seven and eight. A pooled standard diameter is given for each wintering area where sums of D^2 of all animals occurring on an area were pooled. Only animals with five or more relocations during the winter period were used in computing standard diameters for Areas 3 through 6. Only one animal was relocated five or more times on Areas 7 and 8, so animals with four relocations throughout the winter period were pooled to calculate that standard diameter.

Pooled standard diameters for each winter range area are summarized in Table 24. All animals considered were cows with the exception of two calves. Standard diameters for the two calves, one in Area 5 and one in Areas 7 and 8 were not considered separately from the cows as they fell well within the range of standard diam-

eters for cows. No bulls were observed enough times during the winter to compute a standard diameter.

Elk wintering on the Sun River Game Range (Area 3) appeared to have larger ranges than those in the other areas. This probably was due to more area being suitable for winter activities on this area than on any of the others (Figure 14).

The comparatively high standard diameter for Area 5 is probably greatly affected by the shape of the area. Reference to Figure 14 showed that Area 5 and Areas 7 and 8 are comparatively long and narrow. Animals in these areas tend to move from one end to the other resulting in fairly large distances between relocations. The distance from end to end in Areas 5, 7 and 8 is about 6 miles, while their widest width was less than 2 miles. The standard diameter in these areas from any center of activity would include areas outside the boundary of the winter range. As explained by White (1964) the use of a circle of standard diameter does not mean that all of the area included within the circle is used but only that 68.32 percent of the activity of the animal is included within the circle of one standard diameter. The pooled standard diameter for Area 5 describes a circle with a greater area than the entire winter range.

Considerable variation between individual animals also exists as evidenced by the fairly large range in individual standard diameters, especially for Area 3. Enough animals were relocated on Area 3 in both 1964 (7 elk) and 1965 (18 elk) to compare standard diameters between years. The activity centers for both years are

plotted on maps of the area in Figures 16 and 17. The center of activity for the entire area is also indicated and was determined by calculating the geographical center of all the activity centers in the same manner as each individual activity center was calculated. Individual activity centers, standard diameters and relocations for the winter period for ten of the animals are shown in Appendix B.

Standard diameters on Area 3 were smaller in 1965 than in 1964. Table 25 compares pooled standard diameters on Area 3 for 1964 and 1965 as well as four individuals whose standard diameters were computed for both winters. The pooled standard diameter was .48 miles smaller in 1965 and the smallest and largest individual diameters were .87 and .30 miles smaller respectively. Of the four individuals compared for both winters, one had a diameter .03 miles larger in 1965 while the other three had diameters .39 , .75, and 1.16 miles lower in 1965.

The decreased movement in 1965 may be explained by the more severe winter conditions in that year (see Figure 10). It is reasonable to assume that if increasingly severe winter conditions have the effect of concentrating more elk on the winter ranges, it may also restrain their area of movement by making some areas unavailable or less desirable.

Comparison of the centers of activity for the entire area each year, (Figures 16 and 17), shows that the 1965 center was about 0.7 of a mile east of the 1964 center. The eastern 2/3 of this area consists of open grasslands which are usually blown free of snow during

TABLE 24. RANGES OF ACTIVITY OF WINTERING AREAS, JANUARY THROUGH MARCH, 1965.

Area	Pooled Standard Diameter in Miles	Number of Animals	Number of Observations	Range of Individual Diam.
3	3.15	18	113	1.60 - 4.51
4	1.41	4	24	1.19 - 1.60
5	2.85	3	20	2.64 - 3.18
6	1.68	11	65	1.13 - 2.32
7&8	2.26	9	41	-

TABLE 25. COMPARISON OF WINTER STANDARD DIAMETERS ON THE SUN RIVER GAME RANGE FOR 1964 AND 1965.

Animal	Standard Diameters 1964	1965
50	4.81	2.50
52	3.39	2.64
61	4.81	3.65
88	3.41	3.02
All, Pooled	3.63(7) 1/	3.15(18)
Range	2.47 - 4.81	1.60 - 4.51

1/ Sample, number of animals.

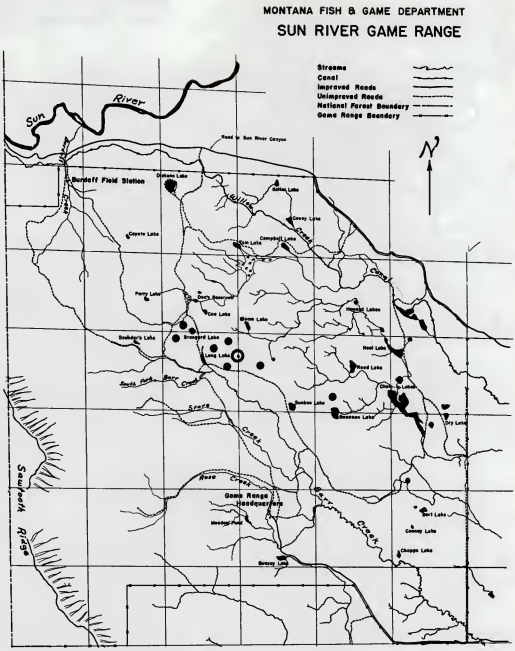

Figure 16. Center of activity for the area and individual activity centers for 7 tagged cow elk on the Sun River Game Range (Area 3) during the 1964 winter season.

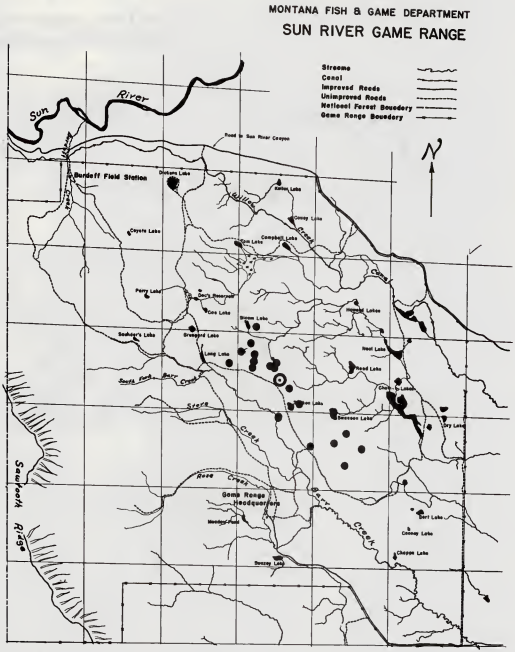

Figure 17. Center of activity for the area and individual activity centers for 18 tagged cow elk on the Sun River Game Range (Area 3) during the 1965 winter season.

any winter while the western 1/3 is timber-covered and likely to hold more snow in a severe winter. The eastward shift of activity centers in 1965 probably reflects less use of the timbered areas during the severe 1965 winter.

SUMMER POPULATIONS

During the summer, the elk are scattered from lower elevation winter ranges to high summer ranges with the majority using the latter (Table 3). Most of the marked animals followed a pattern of migration from winter to spring range and then to summer range. A few stayed on the winter range until the summer, then moved to the summer range.

Most of the elk observed during a summer season appeared to be associated with a specific summer population or area. Only nine relocations on marked animals were made in areas where elk were rarely observed, while 117 marked animals observed during the summer were associated with major population groups. Each marked elk observed on summer range was relocated an average of three times. The maximum number of relocations of a single animal during a summer was seven and the maximum number of a single animal during three summers was eleven.

Elk tended to return to the same summer range each year. Forty-one (32 percent) of the marked animals observed during the summer were found on the same summer range in two consecutive years. Eleven (9 percent) were observed on the same summer range for three consecutive years and six (5 percent) were observed on different

ranges in different years. One animal was observed in three different summer ranges in three summers. The remaining 71 animals or 54 percent were observed only during one summer. Brazda (1953) observed two animals which returned to the same range for two consecutive summers in the Gallatin elk herd. Picton (1960a) observed one animal to use Area F (Figure 19) for two consecutive summers in the Sun River.

The factors influencing the choice by an elk of a summering area is still a matter of conjecture. The migratory pattern of an elk could be formed when it was a calf following its mother or by random choice as a yearling. Murie (1956: 64) apparently believed the pattern is formed as a calf and states:

> "The calf follows the mother the first time; the next time it will be familiar with the same route."

Darling (1964) believed that a close association existed between the hind and the calf, especially the female calf, in red deer but that male calves were more erratic. Martinka (1964) found the movements of marked yearlings to be extremely erratic in the Jackson Hole area. Very little evidence in this study was gained to clarify the point. In each area where a marked yearling was observed during the summer, at least one cow that was neckbanded at the same time also occurred. One cow and calf which were tagged together were observed to stay together throughout the entire winter and part of the spring period. This association dissolved soon after they joined a large group of elk on spring range, but both migrated to the same summer range. This may have been a result of

patterning in the calf, though she could have chosen the summer range by chance. Twelve percent of all the marked elk were observed on the summer range chosen by the calf in question.

Description of Summer Population Areas

Locations of the major population areas are shown in Figures 18, 19 and 20. Areas shown are those where elk were commonly observed during a summer. Separate population areas were determined through tag relocations. Known migration routes between each summering area and the intermediate range are indicated by arrows along with the number of tagged individuals observed to use each route. The most intensively used portion of the intermediate range where most of the intermediate tag observations were made is indicated in Figure 19. Location of the trap where most of the animals were marked is indicated in Figure 20. The largest summer populations and most summer tag relocations were observed in the eight areas A through H. Areas I through N indicate areas where summer populations are known to occur but were not intensively observed. A cow tagged on the Sun River Game Range during the winter of 1964-65 used Area M during the summer of 1965. One animal with distinctive white markings was observed on Area I and was relocated twice there and also enroute up the West Fork of Sun River in the spring migration. Relocations on tagged individuals that did not appear to be associated with a resident summering population are indicated in Figure 20. The more intensively investigated Areas, A through H, will be described separately.

Figure 18. Locations of summer areas A-D. Migration routes between summer areas and intermediate areas are indicated by arrows. Numbers beside lines indicate the number of animals observed on the migration route.

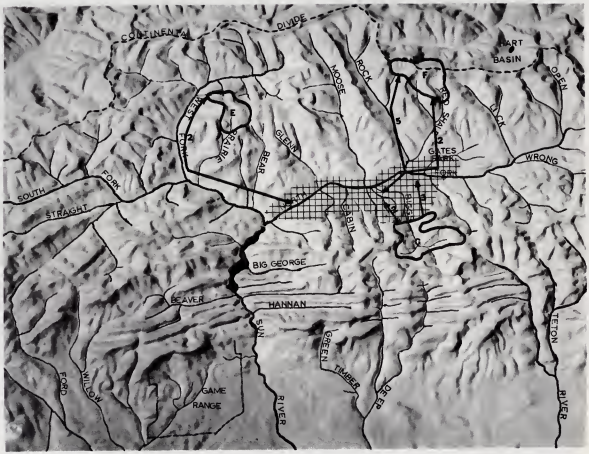

Figure 19. Locations and migration routes for summer areas E-G. Cross-hatched area indicates most intensively used area of intermediate range.

Figure 20. Locations of areas H-N. Site of the trap where most of the elk were marked is indicated by X. Circled numbers indicate marked individuals not associated with known population areas.

Area A, Big George Gulch, overlaps the Big George Winter Range (Area 6, Figure 14). The winter and summer populations of this area are somewhat distinct. Two individuals observed on the Big George winter range were observed on the summer range. Eight tagged animals were observed on this range but only one was observed to use the range for two consecutive years and two of the six erratic animals were associated with this range during one summer. Most of the used portion lies at about 6,200 feet elevation and is characterized by lodgepole and Douglas-fir types with old burns revegetated with shrubs and grasses. The area encompasses approximately 4.24 square miles.

Area B lies at the head of Glenn Creek which drains into the North Fork of Sun River and the head of Girzzley and No Name Gulches which drain into the West Fork of the Sun River. The area encompasses approximately 5.64 square miles at elevations between 7,000 and 8,000 feet. Most of the area was originally a spruce-fir forest type but was burned in the early 1900's and has not reforested. Twelve marked individuals were observed on this summer range, of which seven of them were observed there for two consecutive years and one of them for three consecutive years. Although elk using this range migrate through the North Fork of the Sun River in spring and fall, they apparently did not migrate up Glenn Creek. Most of these tagged individuals were observed to migrate up and down the adjacent Bear Creek drainage which flows into the South Fork of Sun River and thence move north to the North Fork of the Sun River (Figure 19). Two marked elk moved southward from the

summering area through summer range E and then down the West Fork and the South Fork of Sun River to the mouth of Bear Creek and then to the North Fork.

The indirect migration routes may be the result of distribution of vegetation in the area. The lower and intermediate elevations in Glenn Creek are characterized by very dense stands of Douglas-fir and lodgepole pine with very few openings while Bear Creek is characterized by more interspersion of openings containing forbs and grasses with stands of timber. The migration route across summer range E and down the West Fork is also characterized by large areas of grass and forbs interspersed with timber.

Area C, lying at the heads of Moose and Rock Creeks, was the second largest summering area investigated. The area covers approximately 10.64 square miles at elevations at between 7,000 and 8,400 feet. The cirque floor forming the head of Moose Creek, the most commonly used portion of the area, lies at a mean elevation of 7,400 feet. Most of the area was burned in the early 1900's and originally was covered by a spruce-fir timber type. Most of the area now is covered by beargrass and forb types with interspersed pockets of timber. A small area on the ridge separating Moose Creek and Rock Creek is timbered by western larch.

Twenty-seven marked elk were observed on this summer range, five of these were observed during three consecutive summers and five were observed there in two consecutive summers. Migration routes between this area and the intermediate range are fairly direct with most of the elk migrating up and down Moose Creek,

although three marked individuals migrated up and down the adjacent Rock Creek drainage.

Area D covers the lower part of Wrong Creek along with the mouth of Lick Creek and a small portion of the head of the North Fork of Gates Creek. Approximately 6.96 square miles are included. Elevation is fairly low for a summer range, lying between 5,800 and 7,000 feet. Most of the use in the area occurred in the lower portion of Wrong Creek at an elevation of 6,000 feet. The animals moved toward the mouth of Lick Creek and the head of low-lying Gates Creek later in the summer. Vegetation in the area is characterized by Douglas-fir and lodgepole pine with some spruce type at the mouth of Lick Creek. Most of the intensively used area in Wrong Creek has been burned and not regenerated to timber.

Nineteen tagged individuals were observed in this summering area. Two animals were observed to use the area during three consecutive summers and five were observed in this area during two consecutive summers. Half of the elk observed migrating enroute to and from this area moved directly up and down the North Fork of Sun River while the other half moved across Sun River into the Sun River Game Preserve and migrated through Gates Park.

Area E covers the heads of Prairie Creek and the South Fork of Bear Creek which drain into the South Fork of Sun River and the heads of two small creeks draining into the West Fork of Sun River, White Bear Creek and Black Bear Creek. The area is bisected by Prairie Reef, a vertical wall approximately 1,500 feet high at the head of Prairie Creek. Elk are able to travel from the eastern

half via the ridge between Prairie Creek and Bear Creek which extends to the top of the cliff. The area covers 3.64 square miles and lies at elevations between 7,000 and 8,400 feet. Much of the higher portion of the area is characterized by alpine barrens with scattered forbs and grasses. White Bear and Black Bear Creeks are the most intensively used part of the area. White Bear Creek is characterized by Douglas-fir interspersed with grass and forb openings, and Black Bear Creek was entirely burned and has not reforested. The South Fork of Bear Creek is covered by Douglas-fir, interspersed with grass-forbs openings. The head of Prairie Creek which appeared to be the most desirable summer range when compared to ranges used by elk elsewhere is almost entirely old burns with many sub-alpine meadows. Elk use the head of Prairie Creek very sporadically.

Five marked elk were associated with Area E. Three of these were observed in the same area for two consecutive years. Two elk observed to migrate to and from this area went directly to the West Fork, thence down to the South Fork and up to the North Fork.

Area F covers the head of the North and South Forks of Red Shale Creek as well as the head of Baldy Bear Creek, a small tributary to Rock Creek. Animals using this area also use a small portion of the area west of the Continental Divide which, although is characterized by tall steep cliffs, is passable to elk in two places at the head of the North and South Forks of Red Shale Creek. Elevation varies from 7,200 to 8,200 feet. The most commonly used areas, cirques at the heads of the creek drainages, have a mean

elevation of 7,400 feet. Very little of the forest in this summering area has been burned. Most of the area used by the elk is characterized by forb types, high altitude alpine barrens and open canopy spruce-fir.

Eleven tagged individuals were observed on this summer range. Six of them were observed there in two consecutive years. Five elk, observed to migrate to and from this area, moved up and down Baldy Bear Creek and then through Rock Creek to the spring range; while two moved down Red Shale Creek to Gates Park and then to the intermediate range.

Area G covers the upper and intermediate portions of Biggs Creek as well as the head of Sulphur Creek on the east side of the Sun River. Elk in this area were occasionally seen in the head of Headquarters Creek to the north. This and Area A are the only major summer ranges investigated which lie wholly outside of the Sun River Game Preserve. Part of the area used as intermediate range by elk from other areas was included. Vegetation varies from lodgepole pine and Douglas-fir at the lower elevations to very sparse lodgepole pine spruce-fir and Douglas-fir at the higher elevations. Most of the intensively used areas in the head of Biggs Creek were forbs types. The small portion of Headquarters Creek used was a burn area.

Eight tagged elk were observed on this summering area. Five of the tags were seen there in two consecutive years. Since part of the summering area includes a portion of the spring range there is no extensive migration for animals using this area. Although

these animals summer outside of the Preserve they move inside during hunting season. Three animals from this summer range were observed on the intermediate range in the early fall before hunting season. They later were observed inside the Game Preserve after the beginning of hunting season.

Area H is the largest of the summering areas investigated, covering 16.6 square miles at elevations between 6,000 and 8,000 feet. It encompasses the head of the South Fork of Gates Creek at its lowest extremity, the heads of the North and South Forks of Lick Creek as well as part of the North Fork of Red Shale Creek at elevations of about 7,400 feet, and includes considerable area west of the Continental Divide in Hart Basin. There is some overlap between this area and Area F but elk of the two populations do not appear to use the overlap area at the same time of the year. The elk from Area F used that portion of the North Fork of Red Shale Creek in the overlap early in the summer and moved into the South Fork and Baldy Bear Creek later in the summer. Most of the elk using Area H used the portion lying in Hart Basin during late June and most of July, then move southward towards Red Shale Creek in August and back toward the heads of the North Fork and South Fork of Lick Creek in late August and September. Vegetation in Hart Basin was mostly grass and forb with some interspersion of Douglas-fir and spruce-fir. The rest of the area is open and closed canopy spruce-fir type with some Douglas-fir and lodgepole pine in the lower portions of the area. Only one small burn in the South Fork of Gates Creek is within this summer range.

Twenty-eight tagged elk were associated with this summering area. Three animals were observed there in three consecutive summers and nine were observed during two consecutive summers. Migration route to and from this area were varied, though most of the elk observed during migration took the most direct route, through Gates Park, to intermediate range. Six animals from this area were observed to migrate through Moose Creek enroute to and from the intermediate range while one animal migrated through Wrong Creek.

Population Characteristics

Characteristics of the eight major population areas are summarized in Table 26. Estimates of population size for each area were obtained by the same method as explained under winter populations. The estimation procedure does not appear to be as accurate for the summer populations as it was for winter populations. Estimates of the population size are probably somewhat lower than actual populations. Numbers of the eight major areas give a combined total of only 672 animals, leaving more than 1,800 (Table 23) to be accounted for in all other population areas which seems unlikely.

Relative densities were computed by dividing the number of square miles in each area by the population size estimates. Calf: cow ratios were obtained through the estimate, using the same method as used for the total population size. Cumulative ratios are taken from totals of all animals seen in each area throughout the season. Ratios from the population estimates were available

TABLE 26. POPULATION CHARACTERISTICS OF SUMMER RANGE AREAS.

Area	Population	Relative Density 1/	Calf:Cow Ratios From Estimate	Calf:Cow Ratios Cumulative 1964	Calf:Cow Ratios Cumulative 1965
A	78	18	80	43	83
B	97	17	22	33	21
C	114	11	19	25	20
D	81	12	36	25	29
E	72	20	33	36	32
F	75	10	37	22	35
G	55	9	36	--	36
H	100	6	30	37	25

1/ Elk per square mile from population estimate and area enclosed by boundaries shown in Figures 18-20.

for 1965 only. Cumulative calf:cow ratios were available for both 1964 and 1965. There is considerable variation between the cumulative calf:cow ratios observed in 1964 and 1965, especially in the Areas A, B, F, and H. There is no apparent explanation for the variations between years on summer range although sample size and intensity was much greater in 1965 than in 1964.

There appears to be some loss of calves between summer and winter observations. With the exceptions of Areas B and C, the summer ratios are all higher than observed during the winter. Although Areas B and C are both fairly large population areas (third largest and second largest, respectively) it seems unlikely that their proportion in the winter herd would be sufficient to depress the winter calf:cow ratio to the extent observed. Losses in the summer calf crop must come prior to hunting season, since harvests large enough to affect winter age ratios usually have relatively few calves.

A reduction in the calf:cow ratio was not evident through the summer. The calf:cow ratio was observed to increase from July through September in 1964 and also from July through August in 1965. This could be due to sampling procedures combined with differential ranging habits between cows with and without calves. Table 27 tabulates the observed cumulative calf:cow ratio for all areas by month and compares them with sample size. These data clearly show increased monthly calf:cow ratio for both years, and an inverse relationship between calf:cow ratios and sample size.

The increase in calf:cow ratio throughout the summer might

be the best explanation for the variation in ratios between the 1964 and 1965 summers. The cumulative ratios for September, which were the highest in 1964, were not obtained in 1965. The cumulative sample for the 1965 summer might have been higher if the September totals had been added. Comparisons of July and August, 1964 with the same months in 1965 shows that the ratios for the entire area are very similar with 1965 ratios being 1 point lower than the 1964 ratios. Cows with calves or just calves may tend to stay in the more open areas longer and thus are observed out of proportion to their occurrence in the population in August and September when the use of the heavier timbered types increases. If this is the case, the July calf:cow ratios are probably much more representative of the population than the cumulative ratio for the entire summer. This would erase some of the large deficit between the winter ratios and summer ratios.

Another possible reason for the lower calf:cow ratio during the winter might be loss of calves through malnutrition and/or exposure in the late fall. As explained under the harvest section, the animals living in the Preserve habitually stay there even during severe weather until winter snow conditions drive them out. This could be after the conditions have become too severe, or too late for some of the smaller or weaker calves to survive.

There is a very wide difference between the calf:cow ratio in Area A compared to other areas. Table 26 shows a difference of 43 calves per 100 cows between it and the next highest area according to the estimated calf:cow ratios. Significantly, this is the one

TABLE 27. CALF:COW RATIOS ON ALL SUMMER AREAS BY MONTH.

Year	Month	Ratio	Sample Size 1/
1964	July	.29	625
	August	.36	293
	September	.42	217
	Entire Summer	.32	1,135
1965	July	.28	1,030
	August	.35	372
	Entire Summer	.29	1,402

1/ Cows and calves.

TABLE 28. RANGES OF ACTIVITY ON SUMMER AREAS, JUNE 15 THROUGH SEPTEMBER 15, 1964 AND 1965.

Area	Pooled Standard Diameter in Miles	Number of Animals	No. Obs.	Range of Individual Diameters
B	1.46	8	41	1.02 - 1.76
C	2.10	13	74	.88 - 4.20
D	1.52	11	52	1.08 - 1.88
F	1.94	2	9	-
G	2.20	4	21	1.90 - 2.38
H	3.38	5	23	3.00 - 3.66

major summer range that is not closely connected with the Sun River Game Preserve. Area D lies partly outside the Preserve and partly inside, and some of the animals migrate through the Preserve during the hunting season. Area G lies entirely outside of the Preserve but there are indications that at least some of its elk migrate into the Preserve shortly before the beginning of hunting season. Four tags from the latter area were observed inside the Preserve during the fall after the hunting season had begun. It is quite probable that the summer population of Area A is part of the heavily harvested and highly productive segment discussed under Harvest.

One other small population observed outside of the Preserve remained on the Sun River Game Range (Winter Area 3) during the summer. This population had an estimated size of 37 animals (all cows and calves with an estimated calf:cow ratio of 82 and a cumulative observed calf:cow ratio during 1965 of 74). Another very small segment, observed south of Area D, consisted of four cows and four calves for calf:cow ratio of 100. The high calf production outside the Preserve gives weight to the hypothesis given earlier that animals living there are highly productive.

Table 26 also indicates that summering Areas B and C have significantly lower calf:cow ratios than other areas inside the Game Preserve. The fall migratory and ranging habits of elk living in these areas may make them less vulnerable to the harvest than animals in other areas. Elk from these two areas have been observed to stay on the summer range much later in the fall or else

return to it after an initial downward movement in late September.

Four elk from Area B were observed back on their summering area in late October after having previously been observed in late September at the mouth of Bear Creek (see Figure 18). Six elk from Area C were observed on their summering area in late October, through November and into early December after having disappeared from this area for a short period in late September. These animals had not been observed at lower elevations in late September. The only indication that they had moved downward was they were absent from their normal summering range for about 3 weeks. Four elk from Area H were also observed on Area C during the late fall return to the summer range. If production is some function of the harvest rate as indicated in the harvest section a lower calf production could be expected for these areas.

An interesting phenomenon noticed while covering summer observation routes was the apparent lack of elk populations in many otherwise suitable appearing summering areas. Several drainage heads between Areas A and G (Figures 18 and 19) seemed to have very low populations, with only one or two elk occasionally observed. Another series of drainage heads between Areas G and D did not have any apparent populations with the exception of the eight animals mentioned earlier, just south of Area D.

The head of Wrong Creek north of Area D is also a suitable appearing summer range for elk but elk were never observed there, nor did aerial flights and on-the-ground inspection of the area reveal any sign of elk using the area. It is possible that these

areas were once populated and the heavy rate of harvest outside of the Game Preserve precipitated population collapses. The head of Open Creek inside the Preserve (Figure 20) was also characterized by a very low population. Although two marked elk were observed there, a cumulative total of only 32 animals was observed in this drainage during two summers of observation. Both marked animals, a bull and a cow, were harvested in the 1965 hunting season.

Summer Activity Centers

Activity centers and standard diameters were computed for summer range areas in the same manner as for winter range areas. Values are given for both pooled standard diameters by area and for individual animals.

The summer standard diameters are summarized in Table 28. Animals with four or more relocations were used to obtain the pooled estimates. Only animals with five or more relocations on the summer area were considered individually for ranges of standard diameters. Standard diameters are not given for Areas A and E since no individuals were observed more than three times in any one summer.

One animal from Area C was considered as having an abnormal summer ranging habit and not included in the pooled standard diameter. Animal 19 (listed in Appendix C) was normally observed in Area C. In September of 1964 this cow moved 11 airline miles north to Area H and then returned to Area C. This same cow exhibited the same pattern in July of 1965 leaving Area C to go to Area H and then return to Area C within a 2-week period. This abnormal ranging

pattern resulted in a very high standard diameter values for this cow (9.38 miles in 1964 and 8.24 miles in 1965).

The pooled estimates include two, 2-year-old bulls. All others were cows. There was no indication that the two bulls were any more or less active than cows. Their standard diameters were well within the ranges for cows in their summering areas at 1.62 miles for the bull in Area B and 1.74 miles for the bull in Area C.

There is considerable variation among standard diameters listed in Table 28. This is evident both among areas and individuals. The greatest variation was among individuals in Area C with a difference between the largest and the smallest standard diameter of 3.32 miles. Individual variation in other areas was not so great, the next highest difference between individuals on an area was .80 miles in Area D.

Variations in pooled standard diameters among areas might be related to the relative densities within each area, rather than total size of the area as observed for winter range. The largest pooled standard diameter was found on the largest summering area and the smallest on the smallest summer area of those considered in Table 28, but the comparisons between the two extremes do not show such a relationship.

Comparisons of standard diameters of areas with relative densities (Table 26) shows a much closer relationship with the largest standard diameter in the area of the lowest density and the smallest in the area of the highest density. This relationship holds for all of the Areas except C and F which are interchanged

with respect to a linear order. A better sample in Area F where the pooled standard diameter is obtained from only two cows might lower the figure in this area. Higher population densities may inhibit movement on the summer area. White (1964) reports a similar relationship in deer mice (*Peromyscus leucopus*) where larger standard diameters are found at lower population levels.

The pooled standard diameter for all elk observed on summer range is slightly smaller than for all the elk observed on winter range. This is contrary to what might be expected. Elk are usually limited to relatively small concentration areas during the winter compared to summer when they can disperse at will without hindrance of limiting snow conditions. Murie (1956: 292) when discussing carrying capacity states:

> "Elk on summer range have so much country available, move so freely, and are so widely scattered that it has proved next to impossible to determine area needed per head to sustain them.
>
> It has become a truism that winter range is the measure of the possible elk herd. Also, if sufficient range is available one can safely assume there will be adequate summer range."

Cowan (1950) estimates that about 10 percent of the areas of three national parks in Canada is available for elk winter range. The percentage of area available for winter range in the Sun River is about the same. It would be logical to assume that winter standard diameters would reflect the effects of concentrations in being smaller than those for summer, especially in light of the relationship between standard diameters and densities found on summer range.

The pooled standard diameters for winter and summer as well as for 16 individuals whose movements were measured for both seasons are given in Table 29. The pooled standard diameter for winter is .7 of a mile larger than that for summer. Eleven of the 16 animals whose standard diameter was measured both on winter and summer range showed higher ranges of activity during the winter than in the summer. It appears that although the elk have a much greater area to disperse into during the summer, they are limited by their ranging habits to areas as small or smaller than those used during the winter.

Any desnity effect which might limit the size of summer standard diameters is apparently overcome during the winter since although the standard diameter is much larger in the winter the density for each animal is much greater. The number of animals that a cow is associated with at any given time is much larger during the winter than during the summer (Table 13). The extent of forage competition between animals on summer and winter ranges is difficult to assess. Summer areas are characterized by smaller areas of activity and much reduced elk densities, but the pounds per acre of forage produced on the comparatively lush Sun River wintering areas amy result in less actual competition for forage in winter than during the summer.

Relationship Between Winter and Summer Ranges

In view of data presented in the discussion of group constancy (page 73), it would seem unlikely that any particular summer popu-

TABLE 29. COMPARISONS OF WINTER AND SUMMER STANDARD DIAMETERS.

	Standard Diameters	
	Winter	Summer
Pooled for All Animals	2.74	2.04
Animal Number		
8	4.29	2.42
36	2.94	1.14
47	4.18	1.08
49	1.36	2.14
54	2.32	1.54
59	1.77	1.58
66	4.51	1.68
95	2.50	1.50
147	1.41	2.28
159	3.48	1.54
174	4.58	2.04
180	1.81	2.38
185	3.97	1.40
186	2.82	2.48
213	1.64	2.28
215	2.03	3.52

lation would tend to migrate to the same wintering area. If such a relationship did exist between summering areas and wintering areas, that is if elk from particular summering populations tended to migrate to a specific wintering area, knowledge of the relationship would be a valuable aid to management. If the manipulation of a particular summering population was desired, a season could be set that would direct the harvest toward this group on their winter range.

The relationship between winter ranges and summer ranges was tested by means of a contingency table (Ostle, 1956: 68). Winter ranges were arranged in rows and summer ranges in columns (Table 30) and tested for independence against the distribution of χ^2. Observed values in each cell of the table were obtained by placing each animal observed on both a winter and summer area in the row corresponding to the winter range where the elk was observed and the column corresponding to the summer area where the elk was observed. The few elk that changed winter or summer ranges were classified according to the winter or summer area where they were first observed. χ^2 was calculated by the standard formula:

$$\chi^2 = \Sigma\Sigma \frac{(O-E)^2}{E}$$

It appears that summer areas are independent of wintering areas. Calculation of χ^2 for Table 30 showed a value of 26.16. The calculated value of χ^2 does not exceed the tabular value ($\chi^2_{.01(28)} = 48.3$). We must accept the hypothesis that the ob-

TABLE 30. CONTINGENCY TABLE TESTING INDEPENDENCE OF WINTER AND SUMMER POPULATION AREAS. 1/

WINTER AREAS	SUMMER AREAS A	B	C	D	E	F	G	H	
3	**2** *2.63*	**6** *3.76*	**13** *10.16*	**6** *6.77*	**1** *.38*	**2** *2.26*	**1** *1.88*	**7** *10.26*	38
4	**2** *.83*	**0** *1.19*	**5** *3.21*	**1** *2.14*	**0** *.12*	**0** *.71*	**0** *.59*	**4** *3.21*	12
5	**0** *.21*	**0** *.29*	**2** *.80*	**0** *.53*	**0** *.03*	**0** *.78*	**0** *.15*	**1** *.80*	3
6	**2** *1.73*	**3** *2.48*	**3** *6.68*	**7** *4.45*	**0** *.25*	**1** *1.48*	**3** *1.48*	**6** *6.68*	25
7&8	**1** *1.59*	**1** *2.28*	**4** *6.15*	**4** *4.10*	**0** *.23*	**3** *1.36*	**1** *1.14*	**9** *6.15*	23
	7	10	27	18	2	6	5	27	101

1/ Observed values in bold type, expected values in italics.

servations in rows are independent of those in the columns and therefore that animals observed on summering ranges were independent of the distribution on winter ranges. It would not be possible to formulate a management plan whereby animals from a summering area could be harvested through a hunting season on a specific wintering area.

DISCUSSION

The Sun River Elk Herd is not a unique case with respect to low reproductivity. Many low producing herds have been documented in the literature. Poor range conditions, especially winter range, seem to be the most common cause of low production. Part of the elk herd in the Flathead River which lies to the west of the Sun River had very low productivity at 14 calves per 100 cows in the winter of 1965 (Couey and Weckworth 1965). The winter range for these animals is in poor condition, and has been for over 20 years (Gaffney 1941). Cowan (1950) reported calf:cow ratios in Banff Park ranging from 15 to 24, and attributed heavy winter calf losses almost exclusively to malnutrition. Banfield (1949) found indications that severe winter conditions affected the calf crop in Riding Mountain National Park by losses of pregnant cows, stillbirths and reabsorption of embryos.

The Sun River Winter Range

There has been no indication throughout this study that poor winter range condition was responsible for low production in the

Sun River Elk Herd. The Sun River Game Range which winters most of the herd is probably used below capacity.

Utilization figures for 1961, 1962, and 1963 given on pages 55 and 56 show that the most preferred forage, rough fescue, was utilized fairly heavily for 2 years; and the second most preferred forage, Idaho fescue, was utilized lightly to heavily in 1961 and 1962 but very lightly in 1963. Bluebunch wheatgrass, the most abundant plant on the area and third in animal preference, was used lightly at all times and no utilization was found in 1963. Buechner and Swanson (1955) have indicated that bluebunch wheatgrass provided over 90 percent of the winter diet of elk in the Blue Mountains of Washington. It is unlikely that a herd which can leave as much forage unused as the Sun River herd does would be suffering from a winter forage deficiency.

The other wintering areas, with the exception of Areas 1 and 2, are in poorer condition than the Sun River Game Range. However, they winter relatively small numbers of elk. Condition and trend and utilization transects were not available for Areas 4 through 6. Three utilization transects on Areas 7 and 8 indicate that these areas are very heavily utilized each winter and could possibly cause a malnutrition problem. Significantly, these areas did have very low calf:cow ratios compared to the rest of the area in 1963, 1964 and 1965.

A winter nutrition problem would not explain the productivity differences between animals summering in the Game Preserve and those out of the Game Preserve (see sections on harvest, winter populations,

and summer populations). A winter nutritional deficiency should effect all summer ranges equally since the summer distribution of elk is independent of the winter distribution (Table 30).

Influence of the Sun River Game Preserve

There appeared to be a direct relationship between low productivity and those animals living inside the Game Preserve. This relationship has been generally recognized for many years. Janson (1961) in discussing the Sun River Game Preserve states:

> "That hunting harvests and range conditions affect the productivity of big game animals has been demonstrated so many times that this concept is now generally accepted by professional game managers and researchers.
>
> This being true, we should expect the most intensively harvested segment of the Sun River elk herd to be the most productive. Conversely, the least harvested segment, which consists of those animals staying inside the Game Preserve in the summer and most of the hunting season should be the least productive."

Results of this investigation confirm Janson's opinions. Animals from inside the Game Preserve have been lightly harvested and are very low in productivity. Animals ranging outside of the Game Preserve, which now comprise a fairly small segment of the entire population, are heavily harvested and very productive.

Production is now so low that the herd appears unable to maintain itself even in the face of very light harvests. Reference to Figures 10 and 12 will show that both the herd size and the harvest show downward trends. The downward trend in harvest probably reflects both a decline in total numbers in the herd and an increase in the proportion of the total herd belonging to the Game

Preserve segment. The effect of hunting seasons during years of mild fall weather probably results in over-harvest of those animals outside the Preserve, decreasing their proportion of the total population, and thus lowering overall herd productivity. The occurrence of large areas of unused summer habitat outside of the Preserve would indicate that these animals have been heavily harvested.

Possible Effects of the Game Preserve on the Elk Population

So far, I have discussed a general cause and effect between the Sun River Game Preserve and production. Inside the Game Preserve we have a population characterized by low mortality and low natality while outside of the Preserve the population is characterized by high mortality and high natality. This follows the principle of compensation within animal populations as put forth by Nicholson (1933, 1954a, b) and Solomon (1949). However, the specific effect(s) or mechanism(s) through which the Game Preserve acts on the population is not clear.

Density. - One possible result of the lowered harvest rate on the Game Preserve population might be the build-up of an overly high density of individuals. Darling (1964: 37) states that overcrowding results in anti-social behavior which is one type of check to further overcrowding in red deer. Christian *et al.* (1960) have speculated on possible physiological disturbances associated with high population density in sika deer (*Cervus nippon*) which could have been responsible for a population die-off. Leopold (1933: 50)

speaks of a "saturation point" as a maximum wild density attained by a species in favorable environments as a function of the population rather than the environment.

Density of animals did not appear to be a factor in the case of the Sun River Game Preserve. A general knowledge of the gregarious nature of elk along with facts presented in this paper seem to make density *per se* an unsuitable explanation. Effective densities that would act in a psychological way on animals (group size) are never reached within the Sun River Game Preserve that are comparable to those on the Sun River winter range or other winter ranges. Altman (1956b) reports group sizes up to 1,500 head on summer ranges in Wyoming. It is extremely unlikely that a species which can aggregate to such an extent would be limited by the psychological effects of high density. High density summer populations in the Sun River are characterized by low, very high and very low calf:cow ratios (Table 25). The highest density Area (E) shows a calf:cow ratio of 33 while the second highest area for density (A) shows a calf:cow ratio of 80. The only difference being that Area A is outside of the Game Preserve and Area E is inside the Game Preserve.

Age Structure. - Another possible result of a low mortality rate is an age structure characterized by older individuals. Assuming that the harvest is non-selective for age class, an increase in mortality rate results in a younger age structure since animals are being removed from all age classes while they can only be added to the population through the youngest age class. Conversely, a low mortality rate will allow a build-up in the older age classes

in a species with as high a potential physiological longevity as the elk. We have seen this demonstrated in the Sun River area in a difference of harvests between the North Fork and the South Fork. Tables 15 and 16 show an older age structure in the North Fork compared to the South Fork where the harvest is heavier.

There is no way of knowing the age structure for the Game Preserve population as comapred to the non-Preserve population but it can be safely assumed that the structure within the Preserve is much older than that outside of the Preserve. The effects of an older age structure on production are generally believed to be reflected by a lower pregnancy rate in older females. The age at which a cow elk becomes effete is probably quite variable and influenced greatly by nutritional factors. Reference to Table 19 shows that elk that have been harvested in the Sun River are still producing calves at a fairly advanced age. Seventy-five percent of the eight cows between the ages of 9 and 15 were pregnant. A sharp drop in production as indicated by pregnancy was indicated for cows over 15 years old when the pregnancy rate dropped to 40 percent. The pregnancy figures are difficult to interpret since they cannot be separated between the Preserve and non-Preserve animals. Since the pregnancy rate was determined from the harvested animals we can assume that most of them were from the non-Preserve portion, thus explaining the overall pregnancy rate of 70 percent. The absence of Preserve animals from the harvest precludes obtaining a pregnancy rate for them.

The effect of age structure on behavior patterns is largely unknown but could be important. The older age structure within the Game Preserve could result in behavior patterns that are detrimental to production. The presence of older animals in a population could result in more agnostic behavior. Espmark (1964) noted that age was an important consideration within sex groups for the dominance hierarchy in reindeer (*Rangifer tarandus*). Agnostic behavior within harem groups could possibly be an effective deterent to the reproduction of younger cows. Wynn-Edwards (1965) in discussing the effects of the social hierarchy on reproduction states:

> "In fact, not only can the hierarchiall system exclude individuals from breeding, it can equally inhibit their sexual development."

Christian and Davis (1964) discussed the role of social and endocrine factors in the regulation of mammalian populations and stated:

> "The important point in assessing the effects of behavioral factors and adrenal function, is the number of interactions between individuals rather than density of population *per se*. Thus, age, sex, previous experience, local distribution, and other factors may be critical in producing effects."

Further studies directed toward the understanding of behavior patterns or even the documentation of some behavior patterns within harem groups would be a valuable addition to the knowledge of elk population ecology.

Nutritional Deficiencies on the Summer Range

The quantity of summer range available to an elk herd is usually not considered a limiting factor. Murie's (1956: 292) truism

that winter range is the measure of the elk herd has been generally accepted. More recently, Croft and Ellison (1960) have attributed range-watershed deterioration in Wyoming to summer use by elk. It is possible under special conditions such as those in the Jackson Hole region of Wyoming where animals are artificially fed in the wintertime or in the Sun River, where abundant winter range is available, for the herd to have overused concentration areas on the summer range. The summer ranging habits of animals in the Sun River whereby they confine themselves by habit to relatively small areas could result in range overuse. Forage conditions inside the Sun River Game Preserve have shown overuse in places since 1924 (Janson 1961). However, this was usually considered as fall and winter range overuse.

A deficiency in summer range conditions could easily inhibit production. Robinette *et al.* (1955) in discussing mule deer fertility stated:

> "circumstantial evidence indicates that conditions of summer range is of greater importance than condition of winter range in determining fertility of sexually immature does."

Longhurst (1951) in discussing range conditions' influence on big game productivity indicated that forage conditions during and shortly before ovulation could be detrimental to the rate of ovulation.

Much of the Sun River summer range, especially inside the Game Preserve consists of burned areas revegetated by beargrass or spruce-fir with a beagrass-huckleberry understory with only a few forbs

scattered in between. Sub-standard forage conditions could readily occur in some of the areas.

The actual mechanisms through which the presence of the Sun River Game Preserve acts to depress production could be any or several of the factors as discussed above. In any case the cure and effective management of the Sun River Elk Herd would appear to be tied to abolishment of the Sun River Game Preserve.

SUMMARY

1. An investigation was conducted on the Sun River elk herd from 1960 through 1965 to determine causes of low calf production. Early phases of the investigation were concentrated on forage preferences and range relationships. Later phases included the definition of migration routes and population characteristics of different segments of the herd through the use of individually marked animals.

2. Spring range use was characterized by heavy use of grassland types declining toward the end of the season. Spring forage preferences as indicated by feeding site examinations indicated early use of grasses in April declining to heavy utilization of forbs in June.

3. Summer range use was concentrated on high altitude forb and burn types with increasing use of timber types late in the season. Preferred forages on summer range were forbs and grasses which were used in equal amounts.

4. Fall range use was observed to be heaviest on grass types, but the relatively small number of elk observed in October and November indicated that most of the elk were using timber types where they were not easily observed. Fall forage preferences were mainly grasses through October and November with heavy use of browse in bottom and timber types during December.

5. Winter range use was concentrated on grass and savannah types and was quite variable among years according to weather patterns. Winter forage preferences were predominantly for grasses with bluebunch wheatgrass, Idaho fescue, rough fescue and needlegrass forming most of the diet. No evidence of a nutritional deficiency on winter range was found. Forage on the major wintering area was lightly utilized.

6. Individually marked animals were used to aid the study of population characteristics of different segments of the herd and their migratory patterns. The trend in total population from 1957 to 1965 was downward as indicated by analysis of elk counts in relation to winter conditions and population estimates from the marked elk.

7. Data from checking stations indicated that the harvest rate is different for different parts of the herd. The southern portion of the study area is harvested more intensively and shows a younger age sturcture than the northern portion. Animals that summer inside the Sun River Game Preserve often stay there through the hunting season and are very lightly harvested. Calf production is much higher for the animals summering outside of the Game

Preserve which are heavily harvested.

8. Grouping characteristics of the elk were examined in respect to season and vegetative type. Group sizes were greatest during the winter and smallest in early and late summer. Analysis of associations between marked individuals indicated that no two individuals associated with each other for any length of time.

9. Eight winter range areas were examined with respect to population characteristics of the animals using them. Calf:cow ratios varied between years and areas. Marked animals exhibited a tendency to return to the same winter range area each year. Calf:cow ratios were higher in years following heavy harvest indicating that cows from the Game Preserve, which are harvested during heavy harvest years are less productive than cows from outside the Preserve.

10. Most of the tagged elk observed on the summer range occurred on eight summer concentration areas. Most of the summer tag relocations were made inside the Game Preserve. The one summering area with no connection with the Game Preserve had a much higher calf:cow ratio than other areas. Several small summer populations outside the Game Preserve also had very high calf:cow ratios. Most tagged elk returned to the same summer range each year.

11. Centers of activity and standard diameters of activity were measured for both winter and summer ranges. Animals were found to use slightly less area during the summer although much more area is available for dispersal.

12. Composition of winter population groups was independent of that of summer population groups. Elk apparently acted individually when migrating to a particular summer or winter range.

13. Low calf production was chiefly associated with populations within the Sun River Game Preserve. These animals have a low hunting mortality and low natality. Poor nutrition on the summer and fall ranges of these animals might account for the low productivity. An age structure skewed toward older cows may also affect the reproduction of this part of the herd.

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APPENDIX A

Tables for 12 marked elk relocated 20 or more times, giving coefficients of association with other animals by season.

Animal No. 26
Female
Over 3 years in June, 1964
Total Relocations: 23

Associations With Other Animals

Animal Number	Coefficients of Association 1964 Winter	Spring	Summer	Fall	1965 Winter	Spring	Summer
1		.20					
2	.67						
3	.25						
7	.50						
8	.29						
14	.33				.25		
18						.33	
23			.67				
27					.20		
32						.33	
33						.29	
35	.33				.40		
36						.29	
38		.18			.29		
44				.40			
45					.22		
47					.18	.20	
50	.50				.18		
52		.25			.17		
57		.25					
58						.33	

Animal No. 26 (Continued)

Animal Number	Coefficients of Association						
	1964				1965		
	Winter	Spring	Summer	Fall	Winter	Spring	Summer
61				.29	.14		
66		.25		.67	.18	.40	
67							
82			.50	.67			
84			.67				
88	.22				.17		
90	.50						
94					.18		
95					.29		
97							
100							
102		.40					
107			.67				
121		.25					
122					.44		
124	.40						
125					.22		
127					.20		
130						.40	
132					.20		
134	.67				.17	.25	
135					.20		
148			.50				

Animal No. 26 (Continued)

Animal Number	Coefficients of Association						
	1964				1965		
	Winter	Spring	Summer	Fall	Winter	Spring	Summer
149		.22					
158			.40				
161		.20			.17		
163					.55		
164					.40		
167						.33	
169		.15			.22	.40	
170		.20					
171					.50		
172					.17	.29	
173		.17					
179							1.00
181						.40	
185					.17	.25	
192					.36		
221							.33
225						.25	

Animal No. 33
Female
Over 3 years in June, 1964
Total Relocations: 21

Associations With Other Animals

Animal Number	Coefficients of Association 1964 Winter	Spring	Summer	Fall	1965 Winter	Spring	Summer
1		.17					
2		.29					
4		.29					
6		.29					
8			.29				
14					.33		
18						.57	
19			.29				
26						.29	
27		.29			.25	.33	
34			.40				
36						.25	
38		.31					
44		.25					
45			.40				
47						.18	
50		.20			.22		.50
52					.20		
57		.20			.33		
58					.33	.29	

Animal No. 33 (Continued)

Animal Number	Coefficients of Association 1964 Winter	Spring	Summer	Fall	1965 Winter	Spring	Summer
61		.17			.33		
64		.25					
66					.22	.33	
83		.29					
88	.25						
90		.20			.25		
94					.44		
97					.33		
98		.22					
100					.33		
106			.50				
116		.22					
125		.22					
131					.40		
132					.25		
134		.20				.22	
144					.50		
147		.17					
152		.22					
153		.29					
156		.22					
159					.18		

Animal No. 33 (Continued)

Animal Number	Coefficients of Association						
	1964				1965		
	Winter	Spring	Summer	Fall	Winter	Spring	Summer
161		.20			.20		
166					.50		
167					.50		
169		.15				.33	
170		.20			.25		
172					.20	.25	
173		.17	.80				
178					.57		
181					.22	.33	
185					.20	.22	
225						.22	

Animal No. 38
Female
Over 3 years in June, 1964
Total Relocations: 25

Associations With Other Animals

Animal Number	Coefficients of Association 1964 Winter	Spring	Summer	Fall	1965 Winter	Spring	Summer
1		.31					
2		.25					
4		.25					
6	.50	.25					
8	.75						
25		.25					
26		.18			.29		
27	.50	.25			.17		
33		.31					
35							
36	.44						
44		.22					
46					.18		
47	.50				.15		
50	.22	.18			.31		
51					.18		
52	.44	.18					
54					.14		
55					.18		

Animal No. 38 (Continued)

Animal Number	Coefficients of Association 1964 Winter	Spring	Summer	Fall	1965 Winter	Spring	Summer
56		.36					
57					.20	.25	
58							
59					.13		
61	.29	.15			.13		
64		.22					
65	.40						
66	.50	.18			.31		
68					.22		
69					.17	.22	
82					.15		
83		.25					
88					.43		
90		.18			.17		
92					.18		
93					.18	.33	
94	.40				.31		
95					.50		
97					.20		
98		.20					
101	.25						
103					.15	.15	

Animal No. 38 (Continued)

Animal Number	Coefficients of Association						
	1964				1965		
	Winter	Spring	Summer	Fall	Winter	Spring	Summer
116		.20					
119	.50						
121	.29	.18					
122					.18		
123	.67				.18		
124					.18		
125		.20			.36		
126					.17		
127					.17		
130					.18		
131					.14		
134		.18			.14	.44	
135					.17	.40	
143					.18		
147		.15			.14	.25	
152		.20			.17		
153		.25					
156		.20			.18		
157							.40
159					.27		
161	.50	.36			.29		
163					.62		

Animal No. 38 (Continued)

Animal Number	Coefficients of Association						
	1964				1965		
	Winter	Spring	Summer	Fall	Winter	Spring	Summer
164		.20			.33		
165		.13					
168						.33	
170	.50	.18			.17		
171		.25			.20		
172					.29		
173		.31			.17	.57	
178					.18		
180					.13		
181					.31		
182							.25
185						.22	
188					.17		
192					.15	.29	
208					.15		
210					.17		
211							.40
214							.33
215							.33
219					.17		
220					.13		.33

Animal No. 54
Female
Over 3 years old in June, 1964
Total Relocations: 21

Associations With Other Animals

Animal Number	Coefficients of Association 1964 Winter	Spring	Summer	Fall	1965 Winter	Spring	Summer
19						.36	
38					.14		
39					.80	.22	
44			.40				.40
47			.33				
51						.50	
59					.77	.22	
61						.67	
67						.40	
69					.60		
82					.55	.50	
85						.57	
88						.25	
92					.67		
93					.67	.40	
95						.29	
97						.25	
98					.22	.50	
100						.33	

Animal No. 54 (Continued)

Animal Number	Coefficients of Assocation						
	1964				1965		
	Winter	Spring	Summer	Fall	Winter	Spring	Summer
103					.73	.33	
107						.86	
114					.29	.50	
116						.29	
118						.50	
119				.80			
123						.50	
125					.22	.40	
126			.57		.80		
130					.44		
133						.29	
143					.67		
145					.20		
147					.50	.57	
148					.33	.25	
149						.29	.33
151						.57	
152					.60	.40	
153					.29	.50	
156					.44	.25	
158				.80	.44	.20	.40
160							.33

Animal No. 54 (Continued)

Animal Number	Coefficients of Association						
	1964				1965		
	Winter	Spring	Summer	Fall	Winter	Spring	Summer
174					.40		
177						.20	
179						.33	
180					.46		
185							.29
186						.17	
190					.18		
191						.75	
204					.20		
208					.73	.50	
209					.20		
210					.80		
213					.50		
214						.57	
215						.29	
217						.33	
218					.43	.29	
219					.80		
220					.46	.22	
221						.33	
222						.50	

Animal No. 59
Female
Over 3 years old in June, 1964
Total Relocations: 26

Associations With Other Animals

Animal Number	Coefficients of Association 1964 Winter	Spring	Summer	Fall	1965 Winter	Spring	Summer
19						.14	
35		.57					
38					.13		
39					.55	.33	
41		.40					
45		.33					
47		.40					
54					.77	.22	
61						.17	
66							.29
67						.15	
69					.73		
82					.50		
85		.29				.20	
88						.18	.50
90			.50				.33
92		.29			.60	.44	
93					.60	.25	
95						.40	

Animal No. 59 (Continued)

Animal Number	Coefficients of Association						
	1964				1965		
	Winter	Spring	Summer	Fall	Winter	Spring	Summer
97						.18	
98					.20		
103					.67	.13	
107		.33				.20	
114					.25		.33
119						.18	
120		.40					
123						.29	
125					.20		
126					.73	.31	
130					.40		
132		.25					.50
133						.60	
143					.60		
145					.18		
147					.77		
148					.15	.36	
151						.20	
152					.73	.46	
153					.25		
155		.33					
156					.40	.18	

Animal No. 59 (Continued)

Animal Number	Coefficients of Association 1964 Winter	1964 Spring	1964 Summer	1964 Fall	1965 Winter	1965 Spring	1965 Summer
157		.33					
158					.40	.31	
174					.55	.20	.33
177						.15	
178						.18	
179						.22	
180					.71	.29	
186						.13	
190					.33		
191						.18	
204					.18		
208					.83	.36	
209					.36		
210					.73		
213					.62		
214						.20	
215						.40	
216							.25
217						.22	
218					.40	.60	
219					.73		
220					.57		
222						.29	

Animal No. 61
Female
Over 3 years old in June, 1964
Total Relocations: 32

Associations With Other Animals

Animal Number	Coefficients of Association 1964 Winter	Spring	Summer	Fall	1965 Winter	Spring	Summer
1		.17					
2		.29					
4		.29					
6		.29					
7					.22		
14	.50						
18					.20		
19						.29	
26				.29	.14		
27		.29					
32		.29				.22	
33		.17			.33		
35	.50						
36	.20			.29			
38	.29	.15			.13		
39						.17	
40		.22					
44				.25			
45				.29			

Animal No. 61 (Continued)

Animal Number	Coefficients of Association						
	1964				1965		
	Winter	Spring	Summer	Fall	Winter	Spring	Summer
46		.22					
47					.15		
50	.20	.20		.25	.31		
51		.29		.44	.18	.29	
52	.20			.33	.29		
53		.25		.29			
54						.67	
55				.44	.36	.17	
57	.40	.20					
58		.29			.20		
59						.17	
63						.22	
64		.25					
65		.20		.33			
66				.25	.15		
67		.25		.44	.18	.46	
68							
82				.33		.29	
85				.29		.40	
88				.33	.29	.36	
90		.20		.29	.50		
91		.25				.22	

Animal No. 61 (Continued)

Animal Number	Coefficients of Association						
	1964				1965		
	Winter	Spring	Summer	Fall	Winter	Spring	Summer
92				.33			
93					.31		
95				.60	.25	.20	
97						.18	
98		.22				.29	
100				.22		.22	
101	.44			.22			
103		.25				.27	
107						.60	
114				.29		.36	
116						.20	
117					.22		
118						.29	
121	.25				.22		
123		.50		.33	.55	.29	
124	.29				.36		
125		.44				.25	
126		.50				.15	
127					.33		
129				.57			
130		.22					
131					.43		

Animal No. 61 (Continued)

Animal Number	Coefficients of Association						
	1964				1965		
	Winter	Spring	Summer	Fall	Winter	Spring	Summer
132					.50		
133						.20	
134		.20			.57		
135					.33		
144						.25	
145				.33			
146		.29					
147		.17		.44		.40	
148		.22		.29		.18	
149						.20	
151		.29		.29		.40	
152		.22				.31	
153						.29	
155		.25		.33			
156		.22				.18	
158						.31	
159		.25		.22	.33		
160		.25		.33			
161		.20			.14		
163					.15		
166					.50		
167					.33		

Animal No. 61 (Continued)

Animal Number	Coefficients of Association						
	1964				1965		
	Winter	Spring	Summer	Fall	Winter	Spring	Summer
168					.18		
172				.33	.29		
173		.17		.22	.50		
177						.15	
178					.18		
179						.22	
181					.46		
185					.29		
186						.13	
191						.55	
192					.15		
208						.36	
214						.40	
215						.20	
217						.22	
218						.20	
220						.17	
221						.22	
222						.29	
225					.18		

Animal No. 66
Female
Over 8 years old in June, 1964
Total Relocations: 22

Associations With Other Animals

Animal Number	Coefficients of Association 1964 Winter	Spring	Summer	Fall	1965 Winter	Spring	Summer
1		.20					
14					.29		
18					.29	.40	
26		.25		.67	.18	.40	
27					.22		
33					.22	.33	
35					.22		
36		.33		.40		.33	
38	.50	.18			.31		
46					.25		
47					.40	.22	
50					.20		
51				.29			
52		.25			.18		
55				.29	.25		
57		.25			.29		
58					.29	.40	
59							.29
61				.25	.15		

Animal No. 66 (Continued)

Animal Number	Coefficients of Association						
	1964				1965		
	Winter	Spring	Summer	Fall	Winter	Spring	Summer
62						.50	
68					.33		
88					.18		
90				.40			
92				.50			
101		.29					
121		.25					
122				.33	.25	.40	
127		.40					
129				.40			
131					.18		
134						.29	
144					.22		
147				.29			
150							.40
159					.17		
161		.25			.55		
165		.17					
166					.22		
167		.29					
169					.25	.50	
170		.25					

Animal No. 66 (Continued)

Animal Number	Coefficients of Association 1964 Winter	Spring	Summer	Fall	1965 Winter	Spring	Summer
171		.40			.29		
172					.18	.67	
173		.20					
174							.57
178					.25		
181					.20	.50	
185					.36	.29	
188					.22		
192					.40		
216							.44
225						.29	

Animal No. 88
Female
Over 3 years old in June, 1964
Total Relocations: 22

Associations With Other Animals

Animal Number	Coefficients of Association 1964 Winter	Spring	Summer	Fall	1965 Winter	Spring	Summer
1	.17						
3	.31				.25		
7	.22				.29		
8	.33						
14	.36						
19						.15	
26	.22				.17		
27					.20		
32	.25						
33	.25						
35	.18						
36	.15						
38					.43		
41					.25		
45					.22		
46					.22		
47					.18		
50	.31				.36		
51					.22		

Animal No. 88 (Continued)

Animal Number	Coefficients of Association						
	1964				1965		
	Winter	Spring	Summer	Fall	Winter	Spring	Summer
52	.31				.33		
53						.25	
54						.25	
55					.44		
57					.25		
59						.18	.50
61				.33	.29	.36	
65	.22						
66					.18		
67						.17	
68					.29		
85						.22	
90	.44				.20		
93						.29	
94	.22				.18		
95				.33	.57	.22	
97						.20	
101	.17						
103						.14	
107						.22	
117					.29		
121	.18				.29		

Animal No. 88 (Continued)

Animal Number	Coefficients of Association						
	1964				1965		
	Winter	Spring	Summer	Fall	Winter	Spring	Summer
122					.22		
123					.44	.33	
124	.40				.44		
125	.22						
127					.40		
131					.17		
132					.20		
133						.22	
134	.25				.50		
135					.40		
144					.20		
147				.40			
148				.67			
151						.22	
152						.17	
159				.40	.46		
161					.17		
163					.55		
168					.22		
170					.20		
172					.50		
173					.20		

Animal No. 88 (Continued)

Animal Number	Coefficients of Association						
	1964				1965		
	Winter	Spring	Summer	Fall	Winter	Spring	Summer
174						.22	
177						.17	
178					.22		
179						.25	
181					.55		
185					.17		
186						.14	
188					.20		
191						.20	
192					.18		
194						.29	
208						.20	
214						.22	
215						.22	
217						.25	
218						.22	
222						.33	
224						.33	

Animal No. 124
Female
2 years old in June, 1964
Total Relocations: 20

Associations With Other Animals

Animal Number	Coefficients of Association 1964 Winter	Spring	Summer	Fall	1965 Winter	Spring	Summer
3	.22				.18		
7	.46	.29					
8	.25						
14	.29						
18					.40		
19				.67			
26	.40						
35	.57						
36	.22						
38					.18		
41					.40		
50	.44						
51				.33	.33		
55					.33		
61	.29				.36		
65	.40						.33
85		.29					
88	.40				.44		
90	.40				.57		

Animal No. 124 (Continued)

Animal Number	Coefficients of Association 1964 Winter	Spring	Summer	Fall	1965 Winter	Spring	Summer
94		.29					
95					.36		
101	.25						
118							.50
121	.29						
122		.29					
123					.67		
131				.50	.22		
132					.29		
134	.50				.67		
135		.33					
144					.67		
159				.33	.20		
163					.25		
164		.29					
166		.33					
167					.29		
172					.22		
173				.33	.57		
181					.25		
185					.22		
211							.40

Animal No. 124 (Continued)

Animal Number	Coefficients of Association						
	1964				1965		
	Winter	Spring	Summer	Fall	Winter	Spring	Summer
214							.33
215							.33
220							.33
225							.25

Animal No. 147
Female
Over 3 years old in June, 1964
Total Relocations: 27

Associations With Other Animals

Animal Number	Coefficients of Association 1964 Winter	Spring	Summer	Fall	1965 Winter	Spring	Summer
19						.17	
22		.29					
24		.29					.33
32		.29					
33		.17					
36				.33			
38		.15			.14	.25	
39					.40	.20	
44		.25					
45				.33			
46		.67					
49							.67
50				.29			
51		.29		.50	.22	.40	
52				.40			
53		.25					
54					.50	.57	
55				.50			
58		.29					

Animal No. 147 (Continued)

Animal Number	Coefficients of Association						
	1964				1965		
	Winter	Spring	Summer	Fall	Winter	Spring	Summer
59					.77		
61		.17		.44		.40	
65		.20		.40			
66				.29			
67				.25		.18	
69					.60	.22	
82		.29			.55	.40	
83		.29					
84							.29
85				.33		.25	
88				.40			
90				.33			
91		.50					
92				.40	.44		
93					.67	.33	
95				.22			
98		.44			.22	.40	
100						.29	
101				.25		.33	
103		.25			.55	.37	
107						.50	
112					.29		
114				.33		.44	

Animal No. 147 (Continued)

Animal Number	Coefficients of Association						
	1964				1965		
	Winter	Spring	Summer	Fall	Winter	Spring	Summer
116		.44			.25	.25	
118					.20	.40	
123				.40			
125		.22			.22	.33	
126					.60		
129				.67			
130					.44		
133		.29			.29		
143					.44		
145				.40			
146		.29					
148		.22		.33		.22	
149						.25	
151		.29		.33		.25	
152		.22			.80	.18	
153		.29			.29	.40	
155				.40			
156		.44			.67	.22	
158					.44	.18	
159		.25		.25			
160		.25		.40	.22		
161		.20					

Animal No. 147 (Continued)

Animal Number	Coefficients of Association						
	1964				1965		
	Winter	Spring	Summer	Fall	Winter	Spring	Summer
172				.40			
174					.60		
175					.29		
186					.77		.60
190					.18		
191						.44	
192							.33
199							.22
208					.73	.22	
209					.40		
210					.60		
213					.50		
214						.25	
218					.29		
219					.60		
220					.46	.20	

Animal No. 148
Female
3 years old in June, 1964
Total Relocations: 20

Associations With Other Animals

Animal Number	Coefficients of Association 1964 Winter	Spring	Summer	Fall	1965 Winter	Spring	Summer
19						.15	
26			.50				
32		.50			.29		
39					.40	.55	
42					.20		
45				.50			
46		.33					
50				.40			
51		.50		.33	.22	.33	
52				.67			
53		.80					
54					.33	.25	
55				.33			
58		.50					
59					.15	.36	
61		.22		.29		.18	
65		.29		.67			
67				.33			
82			.50				
83					.29		

Animal No. 148 (Continued)

Animal Number	Coefficients of Association						
	1964				1965		
	Winter	Spring	Summer	Fall	Winter	Spring	Summer
85				.50	.44		
88				.67			
91		.40					
92					.22	.50	
95				.29			
98		.33			.44	.33	
101				.33			
103		.40				.14	
106					.29	.33	
107					.50	.22	
114				.50		.20	
116					.25	.22	
118					.60	.33	
123				.67			
125		.33					
126						.50	
129				.50			
133						.44	
140			.67				
145				.67	.80		
146		.50					
147		.22		.33		.22	

Animal No. 148 (Continued)

Animal Number	Coefficients of Association						
	1964				1965		
	Winter	Spring	Summer	Fall	Winter	Spring	Summer
151		.50		.50			
152						.33	
153						.33	
155				.67			
156		.33				.40	
157				.67			
158						.50	
159		.40		.33			
160		.40		.67			
172				.67			
174						.22	
177							
179					.67		
181							
186							
191					.50	.20	
207					.29		
208					.40		
209					.20		
214						.22	
216					.29		
217					.25		

Animal No. 148 (Continued)

Animal Number	Coefficients of Association						
	1964				1965		
	Winter	Spring	Summer	Fall	Winter	Spring	Summer
218						.67	
221						.25	

Animal No. 159
Female
Over 3 years old in June, 1964
Total Relocations: 21

Associations With Other Animals

Animal Number	Coefficients of Association 1964 Winter	Spring	Summer	Fall	1965 Winter	Spring	Summer
7					.25		
19				.40			.33
27					.18		
32		.67					
33					.18		
36							.40
38					.27		
45				.33			
46		.40					
47					.33		
50				.29	.33		
51		.67		.25	.20		
52				.40	.31		
53		.50					
55				.25	.20		
58		.67			.22		
61		.25		.22	.33		
65		.33		.40			
66					.17		

Animal No. 159 (Continued)

Animal Number	Coefficients of Association						
	1964				1965		
	Winter	Spring	Summer	Fall	Winter	Spring	Summer
67				.25			
85				.33			
88				.40	.46		
90					.18		
91		.50					
94					.17		
95			.40	.44	.40		
98		.40					
99				.33			
100							.44
101				.25			
102							.50
103		.50					
112							.20
113		.40					
114				.33			
117					.25		
120							.67
121				.40	.25		
123					.40		
124				.33	.20		
126		.40					

Animal No. 159 (Continued)

Animal Number	Coefficients of Association						
	1964				1965		
	Winter	Spring	Summer	Fall	Winter	Spring	Summer
127					.36		
129				.33			
131				.33	.15		
132					.18		
134					.31		
135					.36		
144					.18		
145				.40			
146		.67					
147		.25		.25			
148		.40		.33			
151		.67		.33			
155				.40			
156		.40					
160		.50		.40			
161					.31		
163					.33		
165					.20		
166					.36		
168					.20		
170					.18		
172				.40	.46		

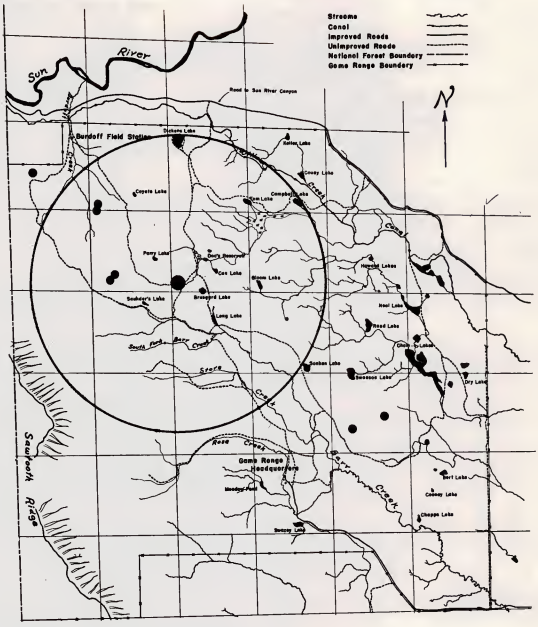
Animal No. 159 (Continued)

Animal Number	Coefficients of Association						
	1964				1965		
	Winter	Spring	Summer	Fall	Winter	Spring	Summer
173				.25	.18		
178					.40		.40
181					.67		
185					.15		
186							.31
191							.25
192					.17		
217							.62
225					.20		.18

APPENDIX B

Winter relocations, centers of activity, and standard diameters for 10 marked elk using the Sun River Game Range.

SUN RIVER GAME RANGE



● 1964 Activity Center

• 1964 Relocations

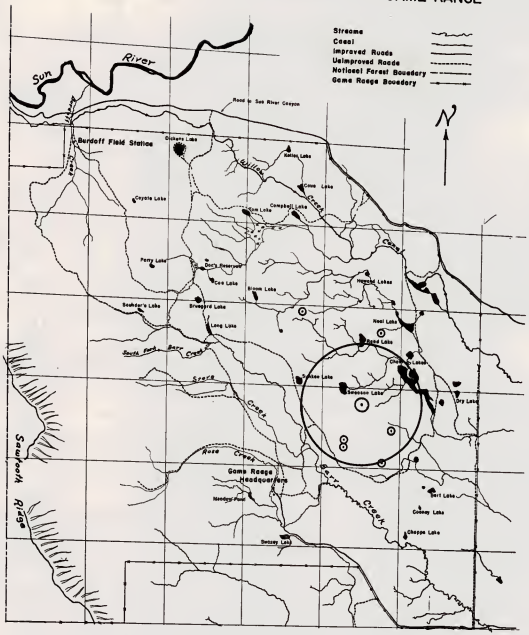
Animal Number 3, Female

Standard Diameter

1964 3.86 Miles - 7 Relocations

MONTANA FISH & GAME DEPARTMENT

SUN RIVER GAME RANGE



⊙ 1965 Activity Center

⊙ 1965 Relocations

Animal Number 26, Female

Standard Diameter

1965 1.60 Miles - 6 Relocations

⊙ 1965 Activity Center

⊙ 1965 Relocations

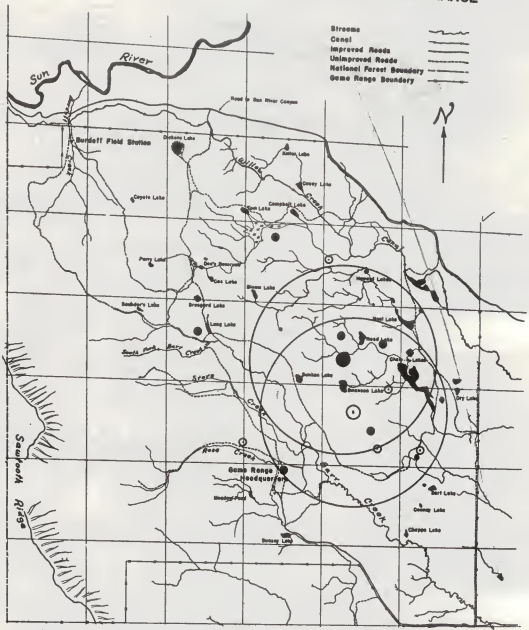
Animal Number 38, Female

Standard Diameter

1965 2.64 Miles - 7 Relocations

MONTANA FISH & GAME DEPARTMENT

SUN RIVER GAME RANGE



● 1964 Activity Center ⊙ 1965 Activity Center

● 1964 Relocations ⊙ 1965 Relocations

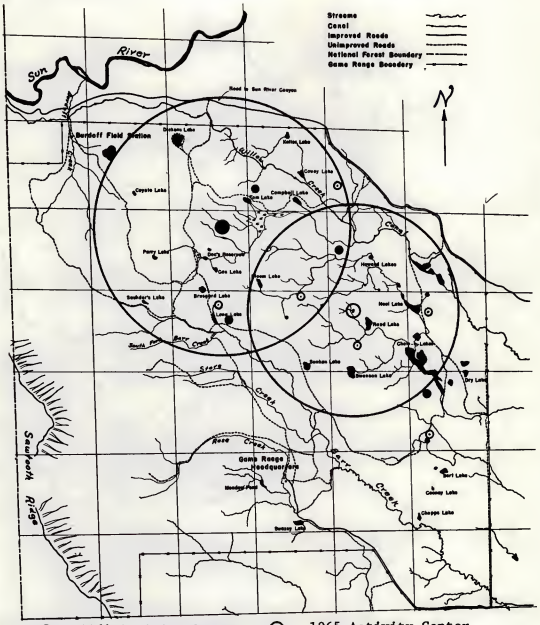
Animal Number 50, Female

Standard Diameter

1964 2.47 miles - 6 relocations

1965 2.50 miles - 5 relocations

SUN RIVER GAME RANGE



● 1964 Activity Center ⊙ 1965 Activity Center

● 1964 Relocations ⊙ 1965 Relocations

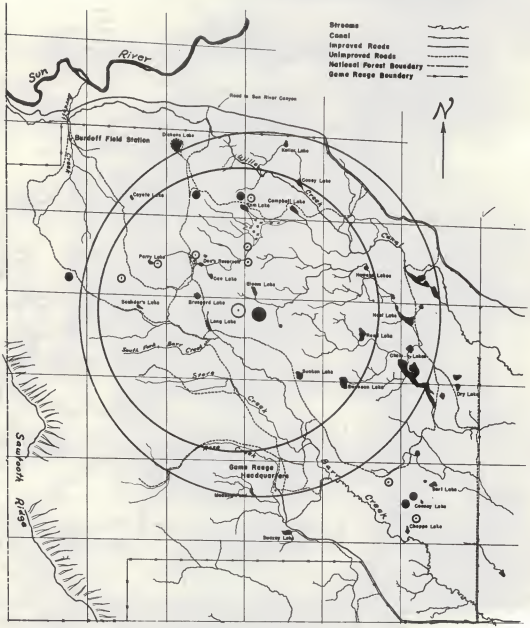
Animal Number 52, Female

Standard Diameter

1964 3.39 Miles - 7 Relocations

1965 2.64 Miles - 6 Relocations

SUN RIVER GAME RANGE



● 1964 Activity Center ⊙ 1965 Activity Center

• 1964 Relocations o 1965 Relocations

Animal Number 61, Female

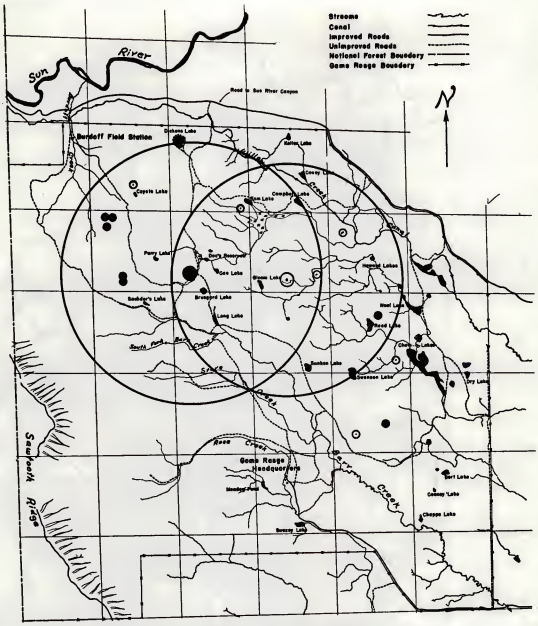
Standard Diameter

1964 4.81 Miles - 5 Relocations

1965 3.65 Miles - 8 Relocations

MONTANA FISH & GAME DEPARTMENT

SUN RIVER GAME RANGE



● 1964 Activity Center

• 1964 Relocations

⊙ 1965 Activity Center

⊙ 1965 Relocations

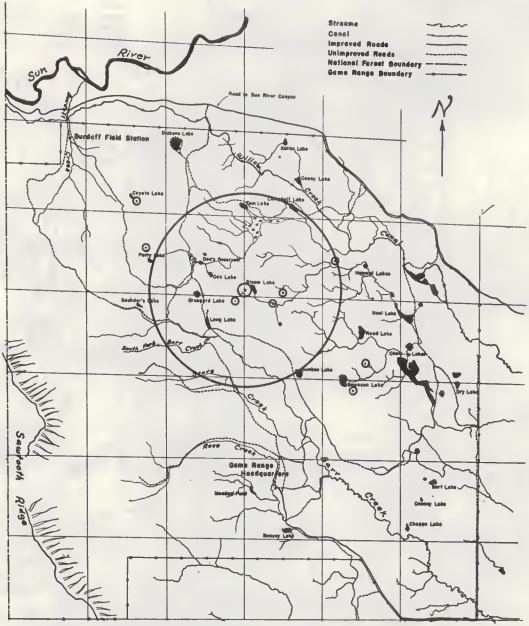
Animal Number 88, Female

Standard Diameter

1964 3.41 Miles - 7 Relocations

1965 3.02 Miles - 6 Relocations

SUN RIVER GAME RANGE



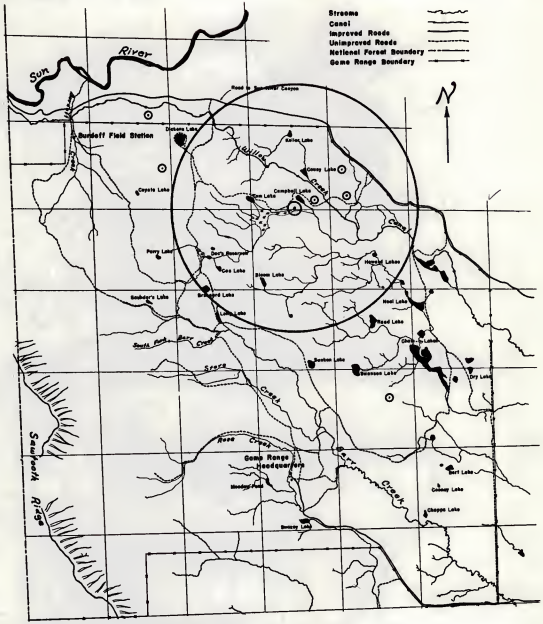
⊙ 1965 Activity Center

⊙ 1965 Relocations

Animal Number 95, Female

Standard Diameter

1965 2.50 Miles - 8 Relocations



⊙ 1965 Activity Center

⊙ 1965 Relocations

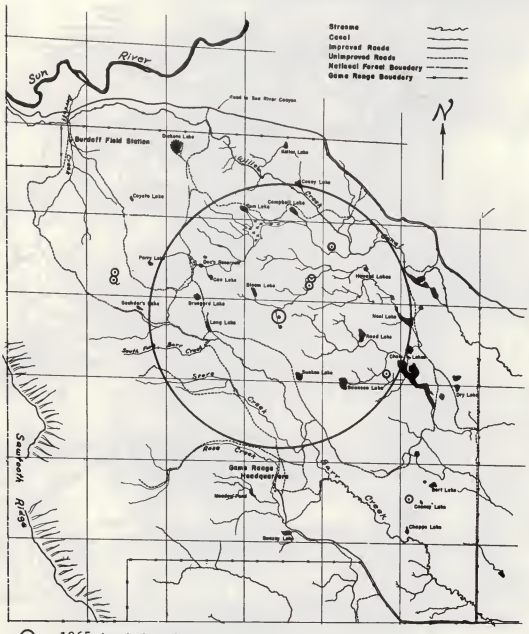
Animal Number 134, Female

Standard Diameter

1965 3.18 Miles - 6 Relocations

MONTANA FISH & GAME DEPARTMENT

SUN RIVER GAME RANGE 226



⊙ 1965 Activity Center

⊙ 1965 Relocations

Animal Number 159, Female

Standard Diameter

1965 3.48 Miles - 7 Relocations

APPENDIX C

Movement Patterns of Ten Marked Elk

○ Winter Relocation

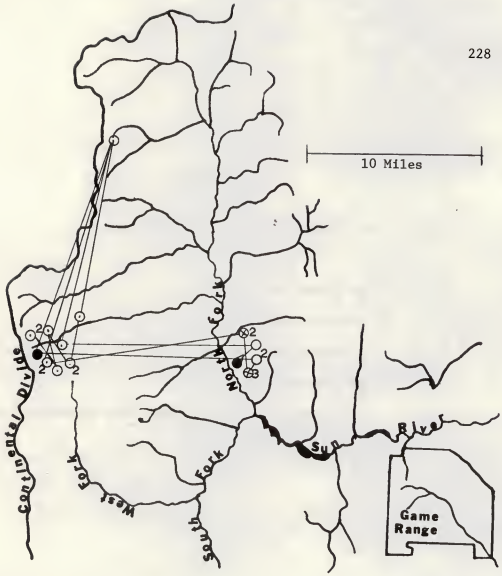
⊗ Spring Relocation

⊙ Summer Relocation

● Fall Relocation

2 Indicates Number of Consecutive Relocations in the Same General Area

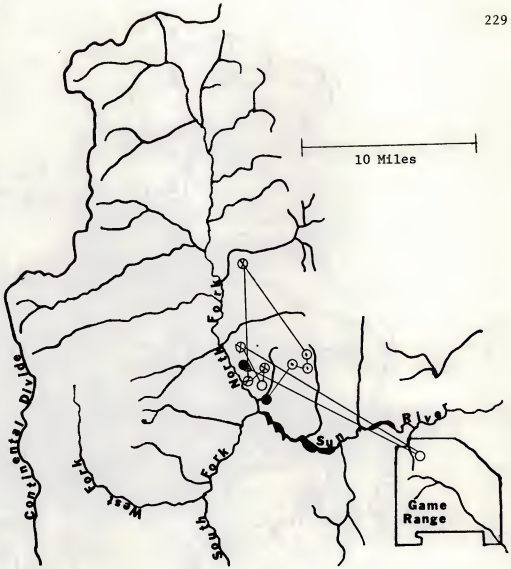
Trap



Animal Number 19, Female

Summer Range - Area C, 3 Summers

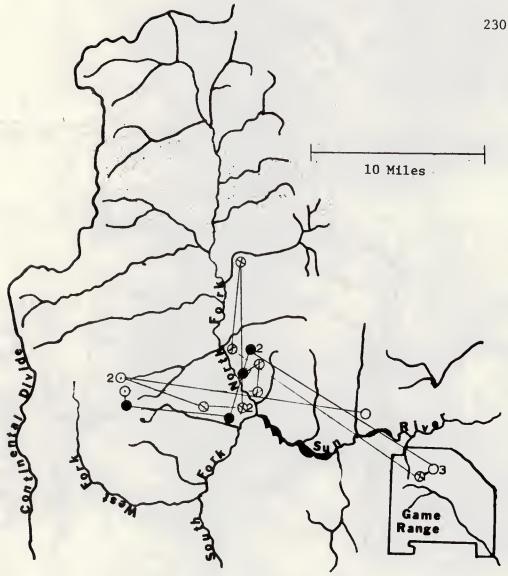
Winter Range - Areas 7 & 8, 2 Winters



Animal Number 32, Female

Summer Range - Area A, 1 Summer

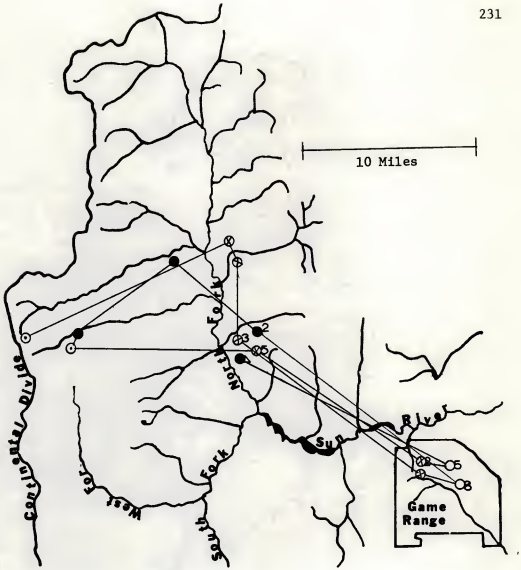
Winter Range - Area 3, 1 Winter



Animal Number 55, Female

Summer Range - Area B, 2 Summers

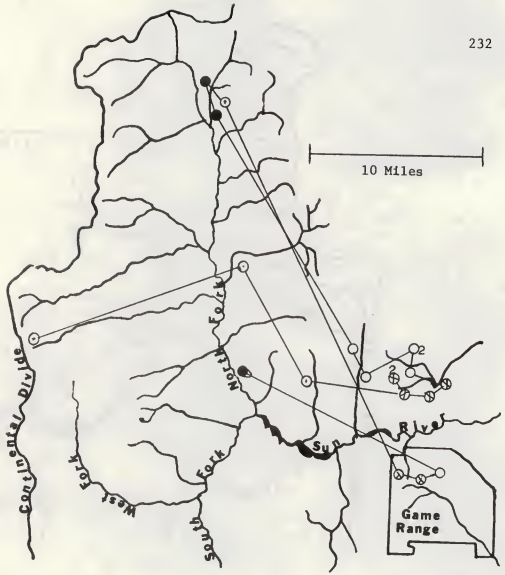
Winter Range - Area 3, 1 Winter



Animal Number 61, Female

Summer - Area C, 2 Summers

Winter - Area 3, 2 Winters



Animal Number 119, Female

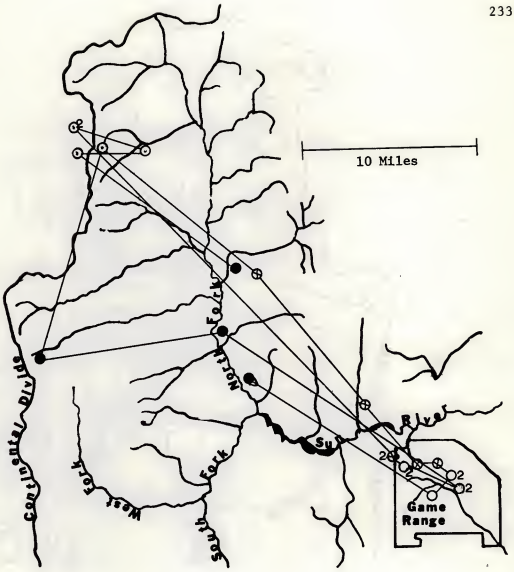
Summer Area - Erratic, D 1964

A 1965

C 1966

Winter Area - Erratic, 3, 1964

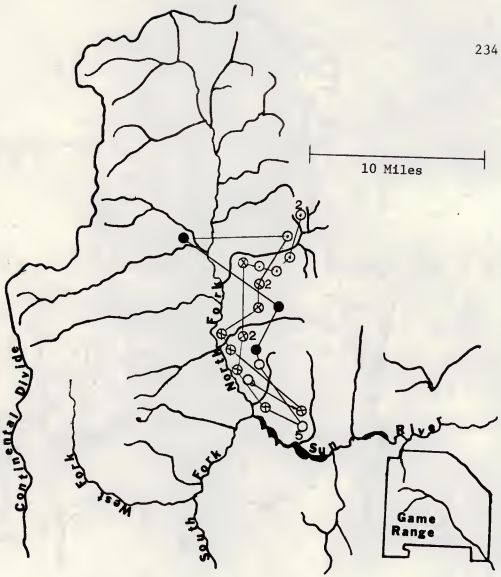
4, 1965



Animal Number 124, Female

Summer Range - Area H, 2 Summers

Winter Range - Area 3, 2 Winters

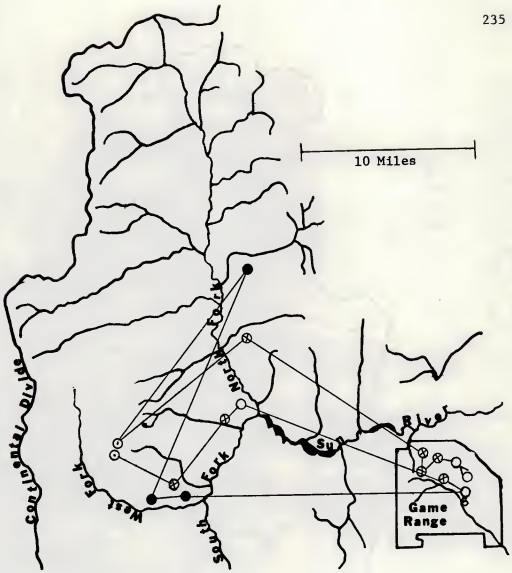


Animal Number 147, Female

Summer Range - Area G, 2 Summers

Winter Range - Areas 7 & 8, 1 Winter

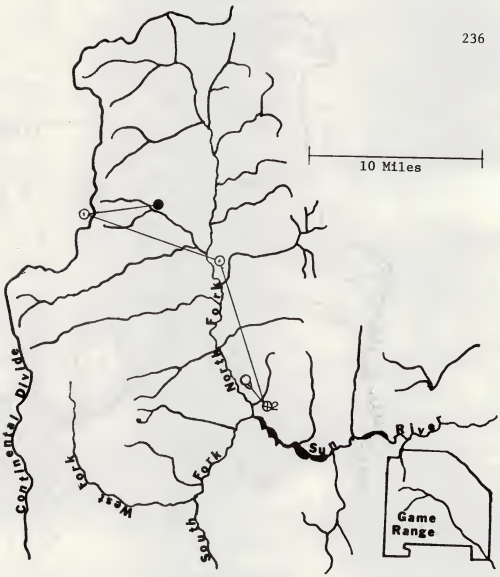
Area 6 1 Winter



Animal Number 161, Female

Summer Range - Area E, 2 Summers

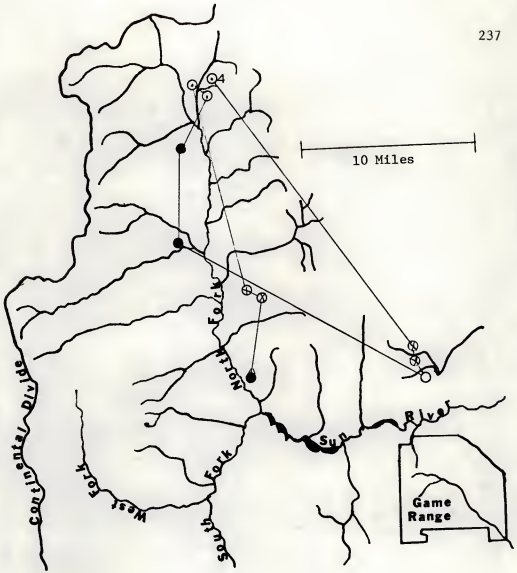
Winter Range - Area 3, 2 Winters



Animal Number 212, Female

Summer Range - Area F, 1 Summer

Winter Range - Areas 7 & 8, 1 Winter



Animal Number 44, Female

Summer Range - Area D, 2 Summers

Winter Range - Area 4, 1 Winter